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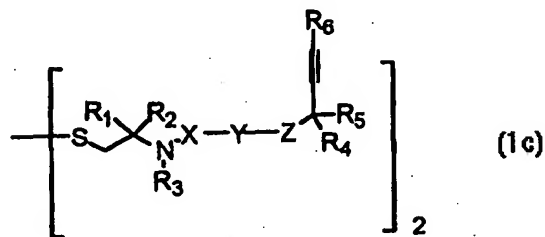
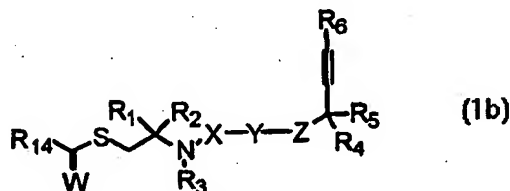
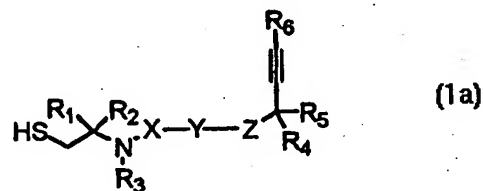
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : C07C 323/49, 327/06, C07D 295/12, C07F 9/53, A61K 31/18, A61P 19/02, 37/00, C07C 309/42, 309/87		A1	(11) International Publication Number: WO 00/44716 (43) International Publication Date: 3 August 2000 (03.08.00)
(21) International Application Number: PCT/US00/02143 (22) International Filing Date: 27 January 2000 (27.01.00) (30) Priority Data: 09/238,393 27 January 1999 (27.01.99) US (71) Applicant: AMERICAN CYANAMID COMPANY [US/US]; Five Giralda Farms, Madison, NJ 07940-0874 (US). (72) Inventors: LEVIN, Jeremy, Ian; 19 Long Meadow Drive, New City, NY 10956 (US). CHEN, James, Ming; 7 Sergeant David Stoddard Court, Bedminster, NJ 07921 (US). (74) Agents: BARRETT, Rebecca, R.; American Home Products Corporation, Patent Law Department - 2B, One Campus Drive, Parsippany, NJ 07054 (US) et al.		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.	

(54) Title: ACETYLENIC SULFONAMIDE THIOL TACE INHIBITORS

(57) Abstract

Compounds of formula (B): (1a), or (1b), (1c) are provided wherein the variables are as defined herein which are useful in disease conditions mediated by TNF- α , such as rheumatoid arthritis, osteoarthritis, sepsis, AIDS, ulcerative colitis, multiple sclerosis, Crohn's disease and degenerative cartilage loss.



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ACETYLENIC SULFONAMIDE THIOL TACE INHIBITORS

FIELD OF INVENTION

5 This invention relates to acetylenic aryl sulfonamide thiols which act as inhibitors of TNF- α converting enzyme (TACE). The compounds of the present invention are useful in disease conditions mediated by TNF- α , such as rheumatoid arthritis, osteoarthritis, sepsis, AIDS, ulcerative colitis, multiple sclerosis, Crohn's disease and degenerative cartilage loss.

10

BACKGROUND OF THE INVENTION

TNF- α converting enzyme (TACE) catalyzes the formation of TNF- α from membrane bound TNF- α precursor protein. TNF- α is a pro-inflammatory cytokine that is believed to have a role in rheumatoid arthritis [Shire, M. G.; Muller, G. W. *Exp. Opin. Ther. Patents* **1998**, 8(5), 531; Grossman, J. M.; Brahn, E. J. *Women's Health* **1997**, 6(6), 627; Isomaki, P.; Punnonen, J. *Ann. Med.* **1997**, 29, 499; Camussi, G.; Lupia, E. *Drugs*, **1998**, 55(5), 613.] septic shock [Mathison, *et. al. J. Clin. Invest.* **1988**, 81, 1925; Miethke, *et. al. J. Exp. Med.* **1992**, 175, 91.], graft rejection [Piguet, P. F.; Grau, G. E.; *et. al. J. Exp. Med.* **1987**, 166, 1280.], cachexia [Beutler, B.; Cerami, A. *Ann. Rev. Biochem.* **1988**, 57, 505.], anorexia, inflammation [Ksontini, R.; MacKay, S. L. D.; Moldawer, L. L. *Arch. Surg.* **1998**, 133, 558.], congestive heart failure [Packer, M. *Circulation*, **1995**, 92(6), 1379; Ferrari, R.; Bachetti, T.; *et. al. Circulation*, **1995**, 92(6), 1479.], post-ischaemic reperfusion injury, inflammatory disease of the central nervous system, inflammatory bowel disease, insulin resistance [Hotamisligil, G. S.; Shargill, N. S.; Spiegelman, B. M.; *et. al. Science*, **1993**, 259, 87.] and HIV infection [Peterson, P. K.; Gekker, G.; *et. al. J. Clin. Invest.* **1992**, 89, 574; Pallares-Trujillo, J.; Lopez-Soriano, F. J. Argiles, J. M. *Med. Res. Reviews*, **1995**, 15(6), 533.], in addition to its well-documented antitumor properties [Old, L. *Science*, **1985**, 230, 630.]. For example, research with anti-TNF- α antibodies and transgenic animals has demonstrated that blocking the formation of TNF- α inhibits the progression of arthritis [Rankin, E.C.; Choy, E.H.; Kassimos, D.; Kingsley, G.H.;

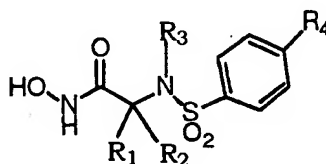
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Sopwith, A.M.; Isenberg, D.A.; Panayi, G.S. *Br. J. Rheumatol.* 1995, 34, 334; *Pharmaprojects*, 1996, Therapeutic Updates 17 (Oct.), au197-M2Z.]. This observation has recently been extended to humans as well as described in "TNF- α in Human Diseases", *Current Pharmaceutical Design*, 1996, 2, 662.

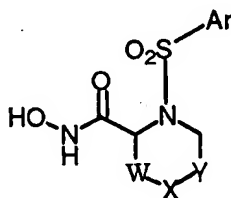
5 It is expected that small molecule inhibitors of TACE would have the potential for treating a variety of disease states. Although a variety of TACE inhibitors are known, many of these molecules are peptidic and peptide-like which suffer from bioavailability and pharmacokinetic problems. In addition, many of these molecules are non-selective, being potent inhibitors of matrix metalloproteinases and, in particular, MMP-1. Inhibition of MMP-1 (collagenase 1) has been postulated to cause joint pain in clinical trials of MMP inhibitors [*Scrip*, 1998, 2349, 20] Long acting, selective, orally bioavailable non-peptide inhibitors of TACE would thus be highly desirable for the treatment of the disease states discussed above.

U. S. patents 5,455,258, 5,506,242, 5,552,419, 5,770,624, and 5,817,822 as well as European patent application EP606,046A1 and WIPO international publications WO9600214 and WO9722587 disclose non-peptide inhibitors of matrix metalloproteinases and/or TACE of which the aryl sulfonamide hydroxamic acid shown below is representative. Additional publications disclosing sulfonamide based MMP inhibitors which are variants of the sulfonamide-hydroxamate shown below, or the analogous sulfonamide-carboxylates, are European patent applications EP-757037-A1 and EP-757984-A1 and WIPO international publications WO9535275, WO9535276, WO9627583, WO9719068, WO9727174, WO9745402, WO9807697, WO9831664, WO9833768, WO9839313, WO9839329, WO9842659 and WO9843963. The discovery of this type of MMP inhibitor is further detailed by MacPherson, *et. al.* in *J. Med. Chem.*, (1997), 40, 2525 and Tamura, *et. al.* in *J. Med. Chem.* (1998), 41, 640.

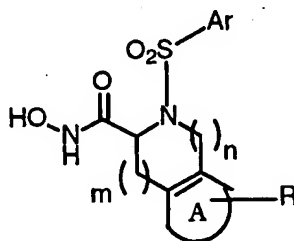


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Publications disclosing β -sulfonamide-hydroxamate inhibitors of MMPs and/or TACE in which the carbon alpha to the hydroxamic acid has been joined in a ring to the sulfonamide nitrogen, as shown below, include U. S. patent 5,753,653, WIPO international publications WO9633172, WO9720824, WO9827069, WO9808815, WO9808822, WO9808823, WO9808825, WO9834918, WO9808827, Levin, *et. al. Bioorg. & Med. Chem. Letters* 1998, 8, 2657 and Pikul, *et. al. J. Med. Chem.* 1998, 41, 3568.

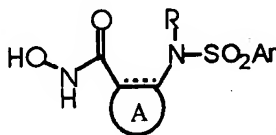


The patent applications DE19,542,189-A1, WO9718194, and EP803505 disclose additional examples of cyclic sulfonamides as MMP and/or TACE inhibitors. In this case the sulfonamide-containing ring is fused to a aromatic or heteroaromatic ring.



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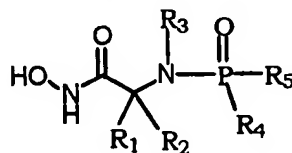
Examples of sulfonamide hydroxamic acid MMP/TACE inhibitors in which a 2 carbon chain separates the hydroxamic acid and the sulfonamide nitrogen, as shown below, are disclosed in WIPO international publications WO9816503, WO9816506, WO9816514 and WO9816520 and U. S. patent 5,776,961.



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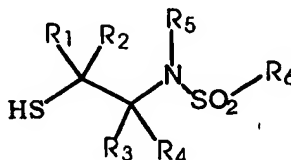
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Analogous to the sulfonamides are the phosphinic acid amide hydroxamic acid MMP/TACE inhibitors, exemplified by the structure below, which have been disclosed in WIPO international publication WO9808853.



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Sulfonamide MMP/TACE inhibitors in which a thiol is the zinc chelating group, as shown below, have been disclosed in WIPO international application 9803166.

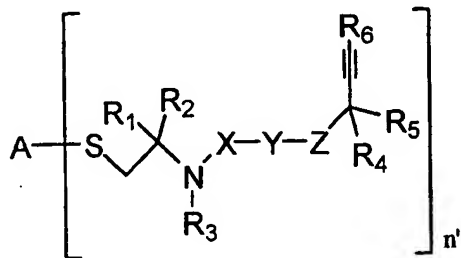


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It is an object of this invention to disclose aryl sulfonamide hydroxamic acid MMP/TACE inhibitors in which the sulfonyl aryl group is para-substituted with a substituted butynyl moiety or a propargylic ether, amine or sulfide.

15 SUMMARY OF THE INVENTION

The invention provides TACE and MMP inhibitors having the formula **B**:



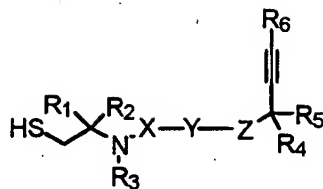
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B

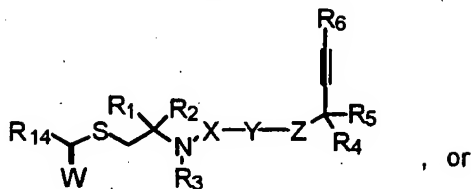
wherein $n' = 1$ or 2 ;
and when $n' = 2$, then A is absent (i.e. a disulfide);
and when $n' = 1$, then A is H or $R_{14}C(=W)-$;

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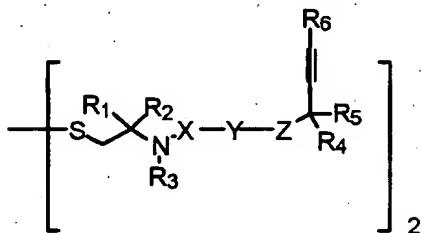
i.e. **B** is one of the following



1a



1b



1c

in which formulae:

5 **W** is oxygen or sulfur;

X is SO_2 or $-\text{P}(\text{O})-\text{R}_{10}$;

10 **Y** is aryl or heteroaryl as defined below, with the proviso that **X** and **Z** may
not be bonded to adjacent atoms of **Y**;

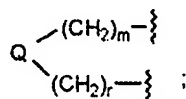
Z is O, NH, CH_2 or S;

15 **R**₁ is hydrogen, aryl, alkyl of 1-6 carbon atoms, alkenyl of 2-6 carbon atoms,
alkynyl of 2-6 carbon atoms;

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R_2 is hydrogen, aryl or heteroaryl as defined below, cycloalkyl of 3-6 carbon atoms, -C5-C8-cycloheteroalkyl, alkyl of 1-6 carbon atoms, alkenyl of 2-6 carbon atoms, alkynyl of 2-6 carbon atoms, or CONR_8R_9 ;

or R_1 and R_2 , together with the atom to which they are attached, may form a ring wherein R_1 and R_2 represent a divalent moiety of the formula:



wherein

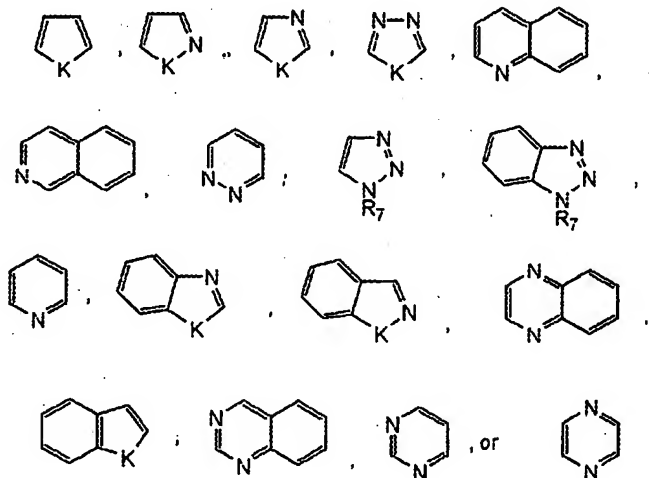
Q = a carbon-carbon single or double bond, O, S, SO, $-\text{N}-\text{R}_{11}$, or $-\text{CONR}_{15}$;

$m = 1-3$;

$r = 1$ or 2 , with the proviso that when Q is a bond, r is equal to 2 ;

Aryl is phenyl or naphthyl optionally substituted by one to two substituents selected from R_7 , where R_7 is as defined below;

Heteroaryl is defined as



optionally mono- or di- substituted by R_7 , wherein K is defined as O, S or $-\text{NR}_{15}$;

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R_3 is hydrogen or alkyl of 1-6 carbon atoms;

or R_1 and R_3 , together with the atoms to which they are attached, may form a 5 to 8 membered ring wherein R_1 and R_3 represent divalent moieties of the formulae:

5



wherein Q and m are as defined above;

10

A is aryl or heteroaryl;

s is 0-3;

u is 1-4;

R_4 and R_5 are each, independently, hydrogen, alkyl of 1-6 carbon atoms, -CN, -CCH;

15

R_6 is hydrogen, aryl, heteroaryl, alkyl of 1-6 carbon atoms, alkenyl of 2-6 carbon atoms, alkynyl of 2-6 carbon atoms, cycloalkyl of 3-6 carbon atoms or -C₅-C₈-cycloheteroalkyl as defined below;

20

R_7 is hydrogen, halogen, alkyl of 1-6 carbon atoms; alkenyl of 2-6 carbon atoms; alkynyl of 2-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, -OR₈, -CN, -COR₈, perfluoroalkyl of 1-4 carbon atoms, -O-perfluoroalkyl of 1-4 carbon atoms, -CONR₈R₉, -S(O)_nR₈, -OPO(OR₈)OR₉, -PO(OR₈)R₉, -OC(O)NR₈R₉, -C(O)NR₈OR₉, -COOR₈, -SO₃H, -NR₈R₉, -N[(CH₂)₂]₂NR₈, -NR₈COR₉, -NR₈COOR₉, -SO₂NR₈R₉, -NO₂, -N(R₈)SO₂R₉, -NR₈CONR₈R₉, -NR₈C(=NR₉)NR₈R₉, -NR₈C(=NR₉)N(C=OR₈)R₉, -NR₈C(=NR₉)N(SO₂R₈)R₉, tetrazol-5-yl, -SO₂NHCN, -SO₂NHCONR₈R₉, phenyl, heteroaryl as defined above, or -C₅-C₈-cycloheteroalkyl as defined below;

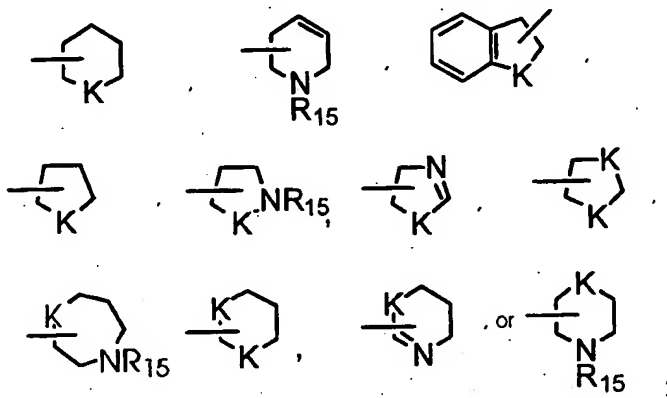
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wherein $-NR_8R_9$ may form a pyrrolidine, piperidine, morpholine, thiomorpholine, oxazolidine, thiazolidine, pyrazolidine, piperazine, or azetidine ring;

5

wherein $-C_5-C_8$ -cycloheteroalkyl is defined as



wherein K is defined as above;

10

R_8 and R_9 are each, independently, hydrogen, alkyl of 1-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, aryl, heteroaryl or $-C_5-C_8$ -cyclohetero-alkyl;

R_{10} is alkyl of 1-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, aryl or heteroaryl as defined above;

15

R_{11} is hydrogen, alkyl of 1-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, aryl, heteroaryl, $-S(O)_nR_8$, $-COOR_8$, $-CONR_8R_9$, $-SO_2NR_8R_9$ or $-COR_8$;

20

R_{12} and R_{13} are independently selected from H, $-OR_8$, $-NR_8R_9$, alkyl of 1-6 carbon atoms, alkenyl of 2-6 carbon atoms, alkynyl of 2-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, aryl, heteroaryl, $-COOR_8$, $-CONR_8R_9$; or R_{12} and R_{13} together form a $-C_3-C_6$ -cycloalkyl of 3-6 carbon atoms or a $-C_5-C_8$ -cycloheteroalkyl ring; or R_{12} and R_{13} together with the carbon to which they are attached, form a carbonyl group;

25

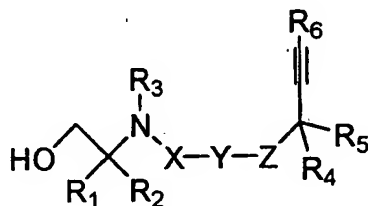
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with the proviso that R_{10} and R_{12} or R_{11} and R_{12} may form a cycloheteroalkyl ring, wherein cycloheteroalkyl is as defined above, when they are attached to adjacent atoms;

- 5 R_{14} is $-OR_8$, $-NR_8R_9$, alkyl of 1-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, aryl or heteroaryl;
 R_{15} is hydrogen, aryl, heteroaryl, alkyl of 1-6 carbon atoms or cycloalkyl of 3-6 carbon atoms;
 and n is 0-2;
 10 or a pharmaceutically acceptable salt thereof.

This invention provides a process for preparing compounds of formula B as defined above which comprises one of the following:

- a) reacting a compound of formula V:



15

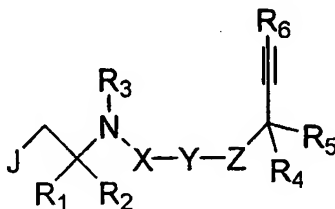
(V)

wherein R_1 - R_6 , X, Y and Z are defined above, with a compound of formula $R_{14}\text{C}(\text{W})\text{SH}$ under conditions suitable for the Mitsunobu reaction to give a corresponding compound of formula 1b (i.e. formula B wherein $n'=1$ and A is

20 $R_{14}\text{C}(=\text{W})-$;

or

- b) reacting a compound of formula VI:



(VI)

25

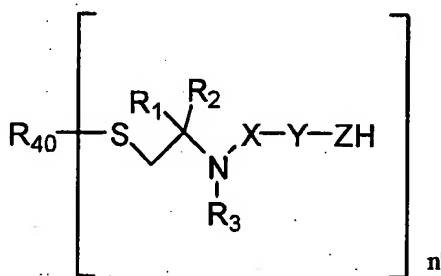
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wherein R_1 - R_6 , X, Y and Z are defined above, and J is a leaving group eg halogen such as chlorine, an organic sulphonyloxy group such as mesylate or tosylate or triflate, with a compound of formula $A'SH$ where A' is an alkali metal or a $R_{14}C(W)-$ group or a salt thereof to give a corresponding compound of formula **1a** or **1b**, (i.e.

5 formula **B** wherein $n'=1$ and A is H or $R_{14}C(=W)-$;

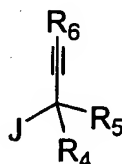
or

c) reacting a compound of formula VII:



(VII)

10 wherein R_1 , R_2 , R_3 , X, Y, Z and n' is as defined above, and when $n'=1$ R_{40} is H or $R_{14}C(=W)-$, and when $n'=2$, R_{40} is absent (i.e. a disulfide), with a compound of formula VIII:



(VIII)

15 wherein R_4 , R_5 , and R_6 are as defined above and J is a leaving group such as described above, to give a corresponding compound of formula **B**;

or

d) hydrolysing a compound of formula **B** wherein R_1 - R_6 , X, Y and Z are defined above, $n'=1$ and A is $R_{14}C(=W)-$ (i.e. formula **1b**), to give a corresponding compound of formula **1a** (i.e. formula **B** wherein A is H);

or

e) reducing a compound of formula **B** wherein R_1 - R_6 , X, Y and Z are defined above, $n'=1$ and A is $R_{14}C(=W)-$ (i.e. formula **1b**) or n' is 2 (i.e. formula **1c**), to give a corresponding compound of formula **1a** (i.e. formula **B** wherein A is H);

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or

f) oxidising a compound of formula B wherein R_1 - R_6 , X, Y and Z are defined above, $n'=1$ and A is H (i.e. formula 1a), to give a corresponding compound of formula 1c (i.e. formula B wherein $n'=2$);

5 or

g) resolving a mixture (e.g. racemate) of optically active isomers of a compound of formula B to isolate one enantiomer or diastereomer substantially free of the other enantiomer or diastereomers;

or

10 h) acidifying a basic compound of formula B with a pharmaceutically acceptable acid to give a pharmaceutically acceptable salt.

With regard to process a), this can be carried out under standard conditions known for carrying out the Mitsunobu Reaction (see Merck Index 12th Edition ONR-
15 61 and references therein) by using suitable reagents such as dialkyl azodicarboxylate, trialkyl- or triaryl-phosphines and for example thioacetic acid.

Process b) can be carried out by processes known in the art suitable for thiolation or thioesterification.

20

Process c) can be carried out by processes known in the art suitable for alkylation, where J is a suitable leaving group such as a halide, or an organic sulphonyloxy group, e.g. mesylate, tosylate or triflate.

25 Process d) can be carried out by processes known in the art, such as using sodium methoxide.

Process e) can be carried out by using the appropriate reducing agent, such as sodium borohydride

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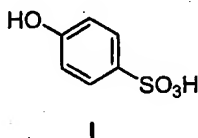
Process f), forming the corresponding disulfide, can be achieved by known processes in the art for oxidation such as the use of air or oxygen.

With regard to process g) standard separation techniques may be used to isolate particular enantiomeric or diastereomeric forms. For example a racemic mixture may be converted to a mixture of optically active diastereoisomers by reaction with a single enantiomer of a 'resolving agent' (for example by diastereomeric salt formation or formation of a covalent bond). The resulting mixture of optically active diastereoisomers may be separated by standard techniques (e.g crystallisation or chromatography) and individual optically active diastereoisomers then treated to remove the 'resolving agent' thereby releasing the single enantiomer of the compound of the invention. Chiral chromatography (using a chiral support, eluent or ion pairing agent) may also be used to separate enantiomeric mixtures directly.

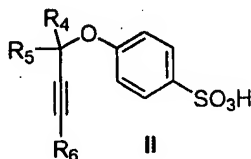
The compounds of formula B may be isolated in the form of a salt of a pharmaceutically acceptable acid, e.g. an organic or inorganic acid by treatment with an acid such as described above."

The invention is further directed to a process for making compounds of structure B involving one or more reactions for preparing intermediates as follows:

- 1) converting a compound of formula I, or a salt or solvate thereof,

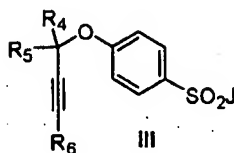


into a compound of formula II



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2) converting a compound of formula **II** above, or a salt or solvate thereof, to a compound of formula **III**:

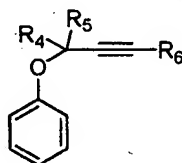


5

wherein J is fluorine, bromine, chlorine, 1,2,4-triazolyl, benzotriazolyl or imidazolyl, and R₄, R₅ and R₆ are as defined above.

The invention is still further directed to a process for making compounds of structure **B** involving one or more reactions for preparing intermediates as follows:

1) converting phenol, or a salt or solvate thereof, into a compound of formula **IV**:



2) converting a compound of formula **IV** above, or a salt or solvate thereof, to a compound of formula **II** above.

Alkyl, alkenyl, alkynyl, and perfluoroalkyl include both straight chain as well as branched moieties. The definitions of alkyl, alkenyl, alkynyl, cycloalkyl and phenyl include alkyl, alkenyl, alkynyl, cycloalkyl and phenyl moieties which are unsubstituted (carbons bonded to hydrogen, or other carbons in the chain or ring) or may be mono- or poly-substituted with R₇. When a moiety contains more than one substituent with the same designation (i.e., alkyl tri-substituted with R₇) each of those substituents (R₇ in this case) may be the same or different. Halogen means bromine, chlorine, fluorine, and iodine.

The compounds of this invention may contain an asymmetric carbon atom and some of the compounds of this invention may contain one or more asymmetric centers and may thus give rise to optical isomers and diastereomers. While shown

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without respect to stereochemistry, the present invention includes such optical isomers and diastereomers; as well as the racemic and resolved, enantiomerically pure R and S stereoisomers; as well as other mixtures of the R and S stereoisomers and pharmaceutically acceptable salts thereof. It is recognized that one optical isomer, including diastereomer and enantiomer, or stereoisomer may have favorable properties over the other. Thus when disclosing and claiming the invention, when one racemic mixture is disclosed, it is clearly contemplated that both optical isomers, including diastereomers and enantiomers, or stereoisomers substantially free of the other are disclosed and claimed as well.

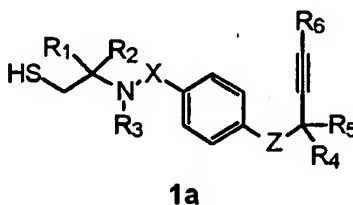
Pharmaceutically acceptable salts can be formed from organic and inorganic acids, for example, acetic, propionic, lactic, citric, tartaric, succinic, fumaric, maleic, malonic, mandelic, malic, phthalic, hydrochloric, hydrobromic, phosphoric, nitric, sulfuric, methanesulfonic, naphthalenesulfonic, benzenesulfonic, toluenesulfonic, camphorsulfonic, and similarly known acceptable acids when a compound of this invention contains a basic moiety. Salts may also be formed from organic and inorganic bases, preferably alkali metal salts, for example, sodium, lithium, or potassium, when a compound of this invention contains an acidic moiety.

Preferred compounds of the invention are those having the formula:

20

B

wherein B is :

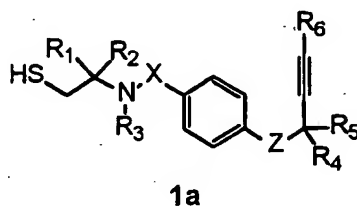


or a pharmaceutically acceptable salt thereof.

25

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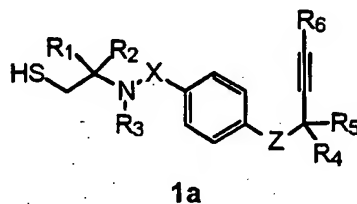
More preferred compounds of the invention are those in which **B** is:



and X is SO₂; or a pharmaceutically acceptable salt thereof.

5

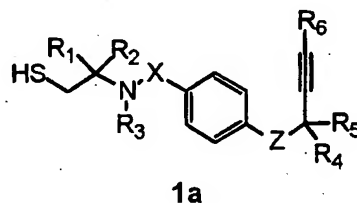
More preferred compounds of the invention are those in which **B** is:



and X is SO₂, and Z is oxygen; or a pharmaceutically acceptable salt thereof.

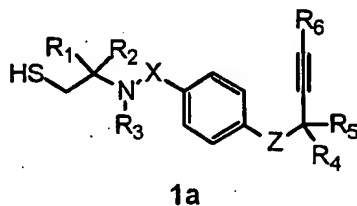
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More preferred compounds of the invention are those in which **B** is:



15 and X is SO₂, Z is oxygen and R₄ and R₅ are hydrogen; or a pharmaceutically acceptable salt thereof.

Still more preferred compounds of the invention are those in which **B** is:

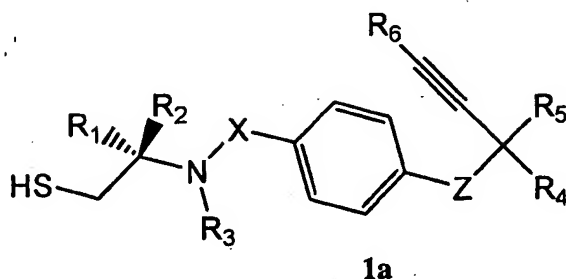


20

and X is SO₂, Z is oxygen, R₄ and R₅ are hydrogen, and R₆ is -CH₂OH or methyl; or a pharmaceutically acceptable salt thereof.

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Still more preferred compounds are those in which B is:



- 5 wherein R_1 is hydrogen, such that this compound has the absolute stereochemistry as shown in structure 1a above.

DETAILED DESCRIPTION OF THE INVENTION

The invention compounds are prepared using conventional techniques known
10 to those skilled in the art of organic synthesis. The starting materials used in preparing the compounds of the invention are known, made by known methods or are commercially available.

Those skilled in the art will recognize that certain reactions are best carried
out when other potentially reactive functionality on the molecule is masked or
15 protected, thus avoiding undesirable side reactions and/or increasing the yield of the reaction. To this end, those skilled in the art may use protecting groups. Examples of these protecting group moieties may be found in T. W. Greene, P. G. M. Wuts
"Protective Groups in Organic Synthesis", 2nd Edition, 1991, Wiley & Sons, New
York. Reactive side chain functionalities on amino acid starting materials are
20 preferably protected. The need and choice of protecting groups for a particular reaction is known to those skilled in the art and depends on the nature of the functional group to be protected (hydroxy, amino, carboxy, etc.), the structure and stability of the molecule of which the substituent is part and the reaction conditions. Those skilled in the art will recognize that the nature and order of the synthetic steps
25 presented may be varied for the purpose of optimizing the formation of the compounds of the invention.

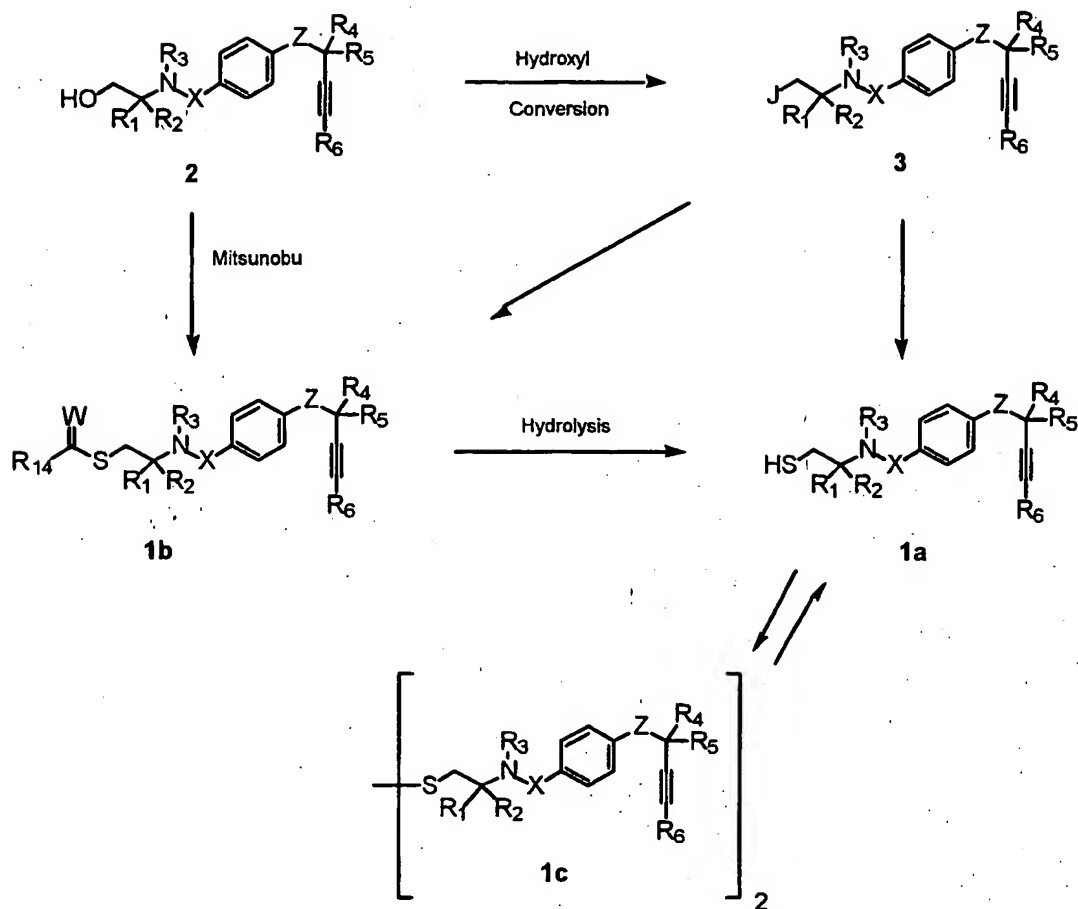
When preparing or elaborating compounds of the invention containing aryl, heteroaryl or heterocyclic rings, those skilled in the art recognize that substituents on that ring may be prepared before, after or concomitant with construction of the ring. For clarity, substituents on such rings have been omitted from the schemes herein
5 below.

The thiol compounds of the invention, **1a-1c**, are prepared according to Scheme 1 by converting an alcohol, **2**, into the corresponding thioester or dithioester, **1b**, via a Mitsunobu procedure using reagents such as triphenylphosphine, diethyl azodicarboxylate and thiolacetic acid. Conversion of **1b** into thiol **1a** is
10 accomplished through hydrolysis or reductive cleavage of the ester using sodium methoxide, sodium borohydride or similar reagents. Thiol **1a** may be converted into the corresponding disulfide using methods compatible with acetylenic substituents, such as oxidation with air or oxygen.

Alternatively, the alcohol moiety of **2** can be converted into a leaving group J, where J is a halide, tosylate, mesylate, triflate or similar functionality to give
15 compound **3**. Reaction of **3** with nucleophiles such as sodium sulfide, thiolacetic acid, dithiolacetic acid, or similar agents or their salts, then provides **1a** or **1b**.

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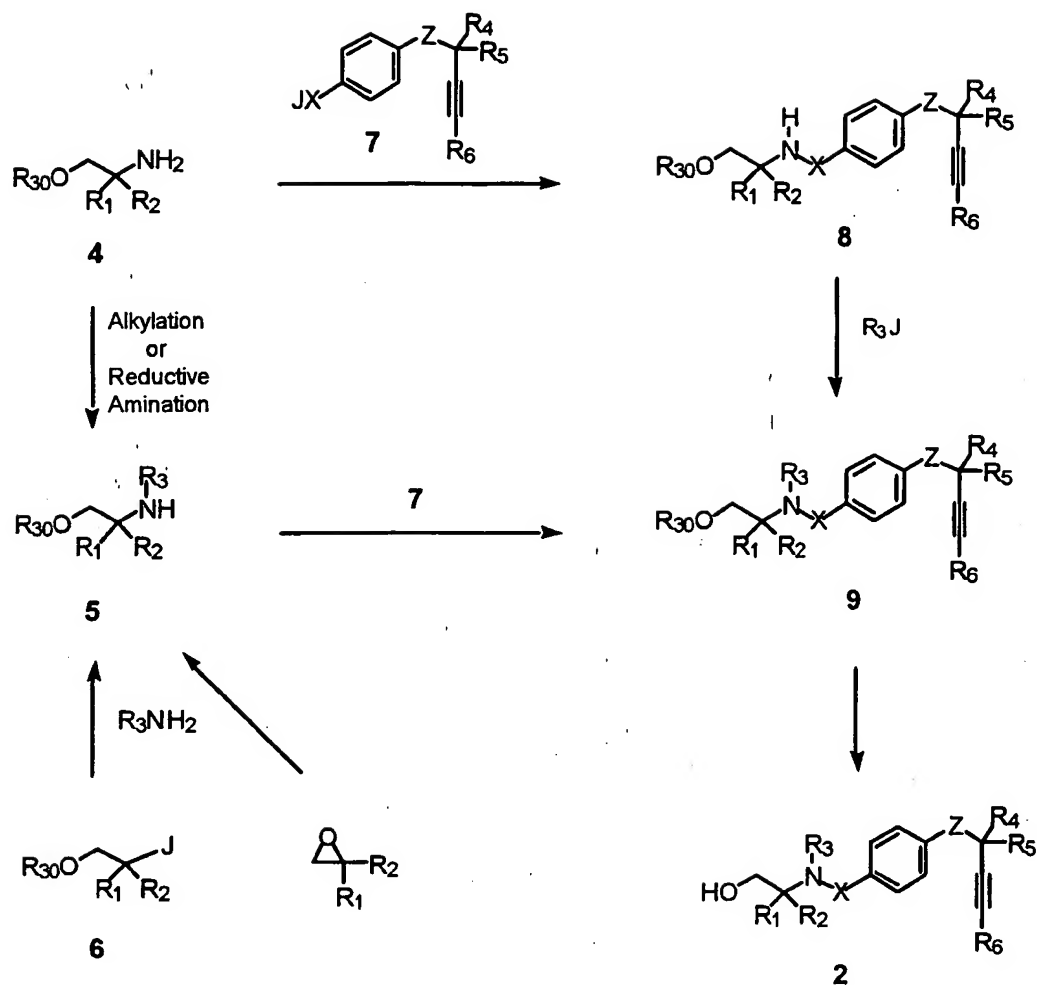
Scheme 1:



- Alcohols **2** may be prepared as shown in **Scheme 2**. Amino-alcohol **4** ($R_{30} = H$), or its hydroxyl protected analog wherein R_{30} is a suitable masking group such as trialkylsilyl or tetrahydropyran can be sulfonlated or phosphorylated with **7**, wherein **J** is as described in **Scheme 1**, in the presence of a tertiary amine base, or pyridine, to provide **8**. Alkylation of N-H compound **8** with R_3J and a base such as potassium carbonate or sodium hydride in a polar aprotic solvent such as acetone, N,N-dimethylformamide (DMF), or tetrahydrofuran (THF) provides sulfonamide **9**.
- Compound **9** is also available through direct reaction of **7** with an N-substituted amino-alcohol derivative, **5**. Compound **5** is available via alkylation or reductive alkylation of amine **4**, or by amination of **6** or the corresponding epoxide. Conversion of **9** into the alcohol is then performed in a manner consistent with the choice of protecting group R_{30} and the presence of a carbon-carbon triple bond.

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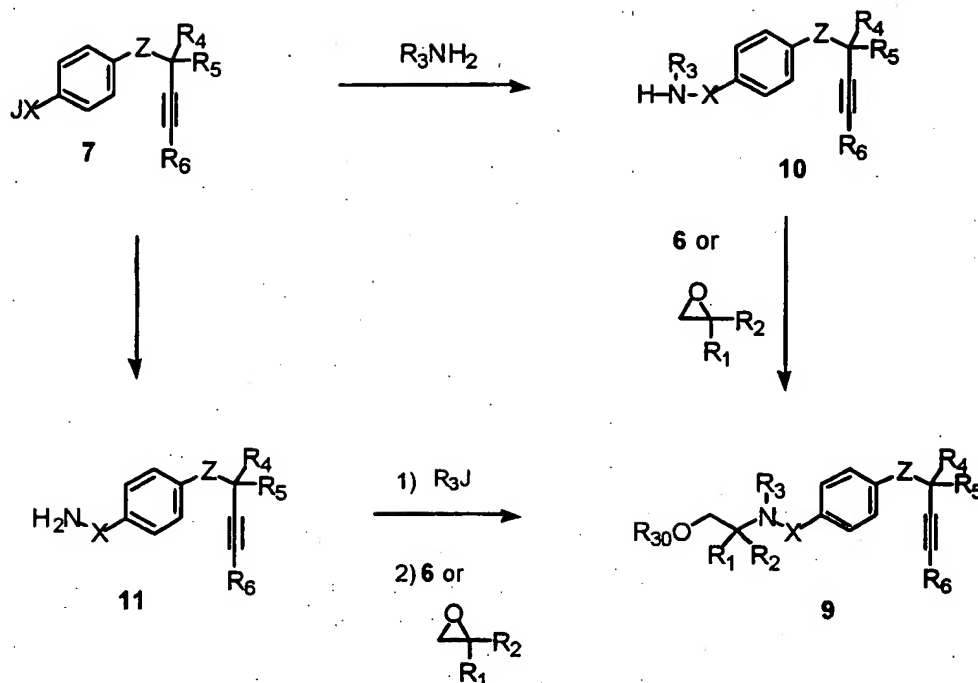
Scheme 2:



Another route to compounds 9 is shown in Scheme 3. Compound 7, for example the sulfonyl chloride, can react with a primary amine or ammonia to give compounds 10 or 11, respectively. Alkylation of 10 with 6 or an analogous epoxide provides 9 directly, whereas 11 can be alkylated with R_3J followed by 6 (or vice versa) or an epoxide to give 9.

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Scheme 3:

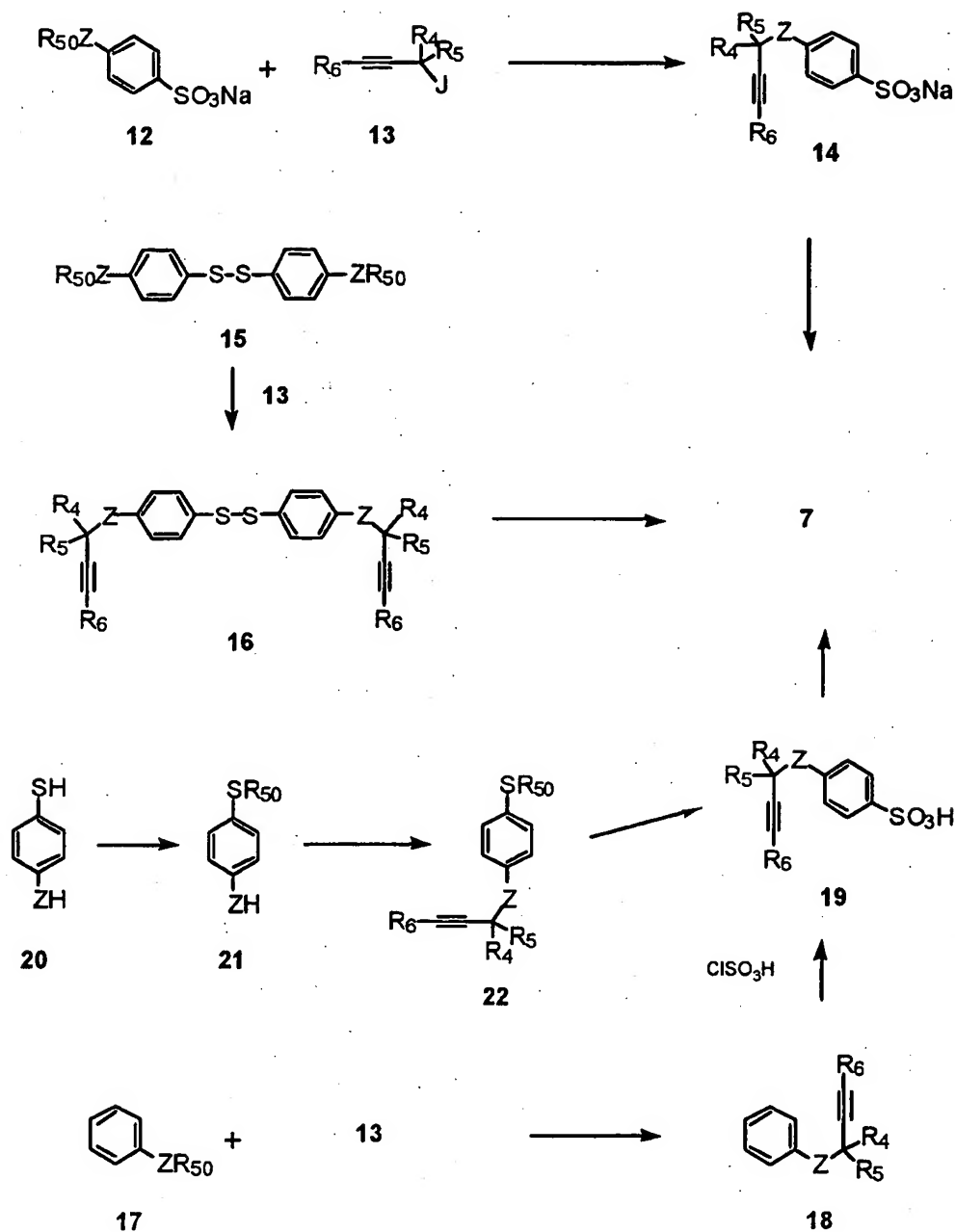


Methods of preparation of sulfonylating agents 7 are shown in Scheme 4. Thus, sulfonic acid salts 12, where ZR_{50} is a hydroxy, thiol or substituted amino moiety may be alkylated with acetylenes 13, where J is a suitable leaving group such as halogen mesylate, tosylate, or triflate to give 14. Acetylenes 13 are commercially available or known compounds, or they may be synthesized by known methods by those skilled in the art. The sulfonic acid salts 14 may be converted into the corresponding sulfonyl chloride or other sulfonylating agent 7 by known methods, such as reaction with oxalyl chloride or other reagent compatible with substituents R_4 , R_5 , and R_6 and the acetylene. Alternatively, the disulfide 15 may be converted into diacetylene 16 by reaction with compounds 13, followed by reduction of the disulfide bond to provide the analogous thiols which may be converted into 7 by known methods. Alkylation of the phenol, thiophenol, aniline or protected aniline 17 with 13 to give 18, followed by reaction with chlorosulfonic acid provide sulfonic acids 19 which are readily converted into 7 with oxalyl chloride or similar reagents. Thiophenols 20 are also precursors to 7 via protection of the thiol, alkylation of ZH,

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where Z is O, N or S, and deprotection of the sulfur followed by oxidation to the sulfonic acid **19**.

Scheme 4:

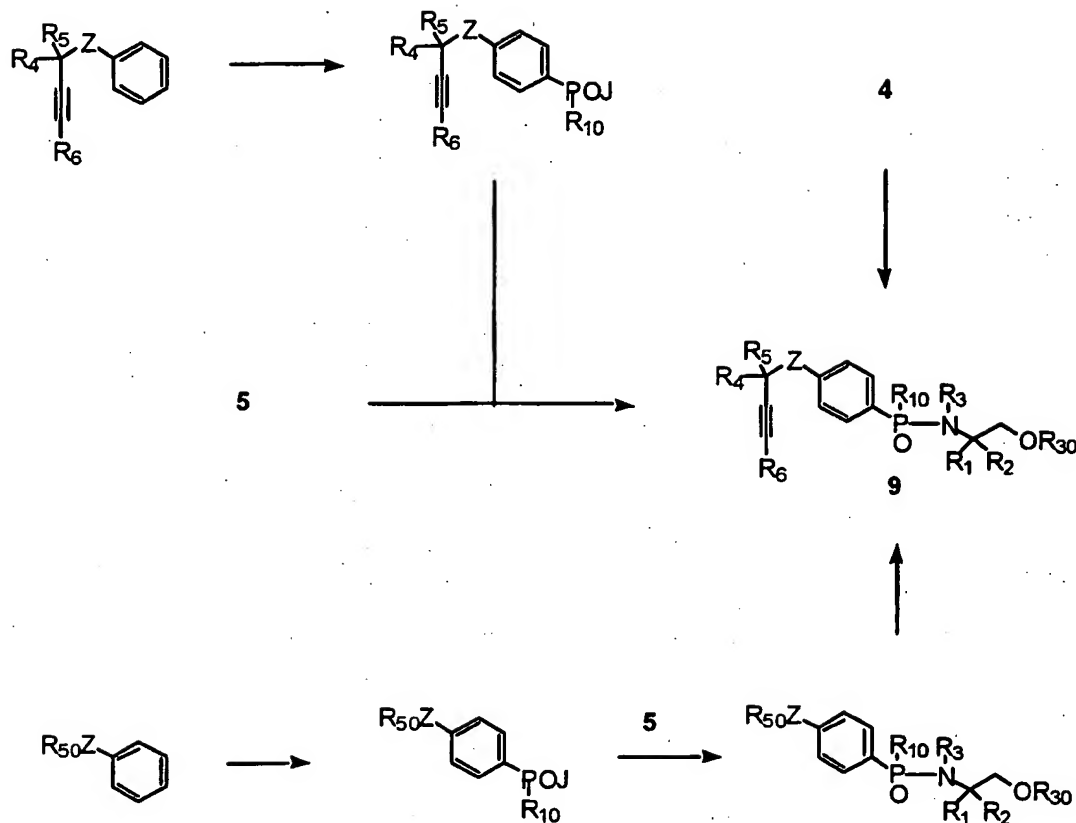


5

The phosphorus containing analogs of **7** may be prepared using similar methodology, as shown in **Scheme 5**.

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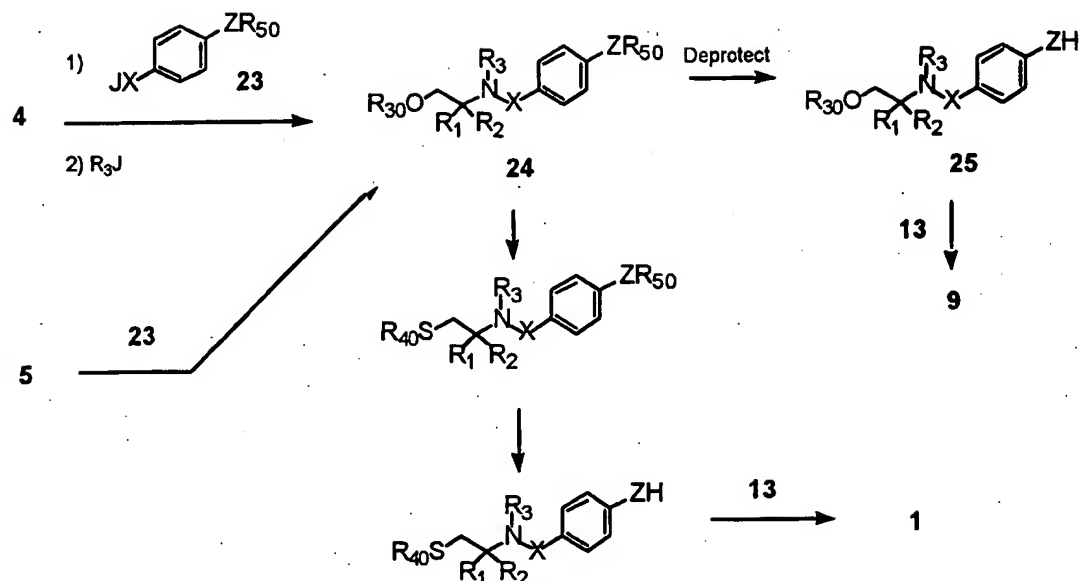
Scheme 5:



The acetylenic side chain may also be appended after sulfonylation or phosphorylation of the amino acid derivative, as shown in Scheme 6. Thus, the amino-alcohol derivatives 4 and 5 can be sulfonylated or phosphorylated with compounds 23, where ZR₅₀ is hydroxy or protected hydroxy, thiol or amine, and, if necessary, alkylated as in Scheme 2, to give 24. Removal of the R₅₀ masking group to give 25 and subsequent alkylation of the resulting phenol, thiol or amine with 13 provides 9. In the case where ZR₅₀ is equal to OH, no deprotection step is required to give 25. Alternatively, the OR₃₀ moiety of 24 may be converted into the analogous thioester, thiol or disulfide, as shown in Schemes 1 and 2, prior to deprotection of the ZR₅₀ moiety of compound 24. Subsequent alkylation of the unmasked -ZH group would then provide the compounds of the invention.

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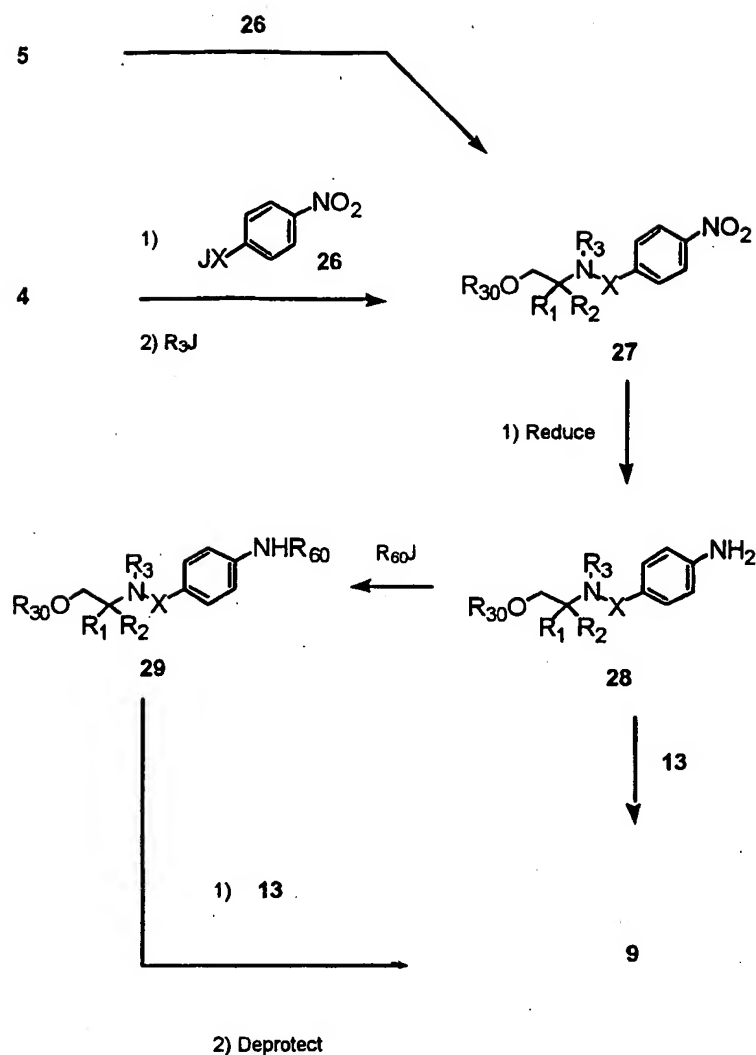
Scheme 6:



The propargylic amine analogs of 9 can be synthesized as shown in Scheme 7 starting from the amino-alcohol derivatives 4 and/or 5. Sulfonation or phosphorylation with para-nitro aryl compound 26, for example 4-nitrobenzenesulfonyl chloride, followed by alkylation with R_3J (for 4) using a base such as potassium carbonate or sodium hydride in DMF provides 27. Reduction of the nitro moiety with hydrogen and palladium on carbon, tin chloride or other known method to give aniline 28 and subsequent alkylation with 13 then provides 9. Aniline 28 may also be derivatized (29) prior to alkylation with 13 and then deprotected after the alkylation step. As in Scheme 6, compound 29 can first be converted into its thioester, disulfide or protected thiol analog, followed by appending the propargyl group, via alkylation with 13, and subsequent deprotection of the aniline to provide compounds 1a-1c of the invention.

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Scheme 7:

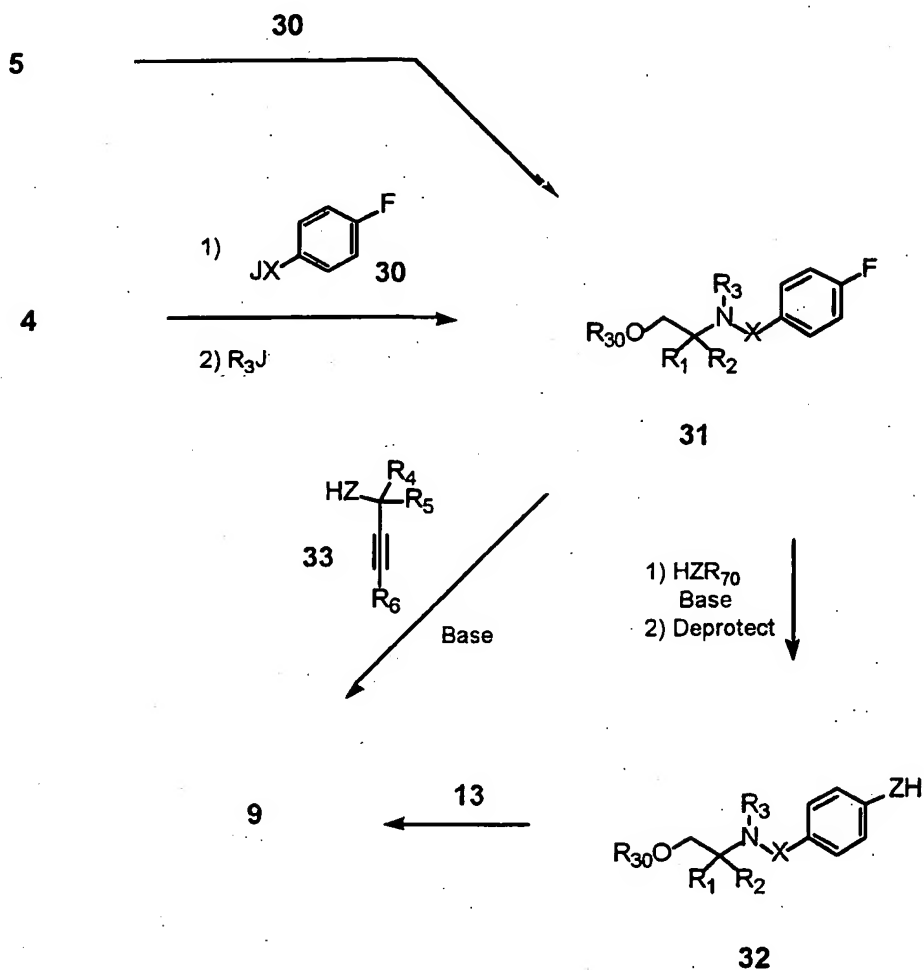


Acetylenic derivatives **9** are also accessible via the fluoro compounds **31**, readily prepared from the amino-alcohol derivatives **4** and/or **5** by reaction with fluoroaryl **30**, as shown in Scheme 8. Displacement of the fluorine of **31** in the presence of a base such as sodium hydride with a masked hydroxy, thiol, or amino group (HZR_{70} , where R_{70} is a suitable protecting group) in a polar aprotic solvent such as DMF, followed by deprotection gives **32**, which can then be alkylated with **13** to provide **9**. Conversion of **31** to **32**, where Z is sulfur, might also be accomplished with Na_2S , K_2S , $NaSH$ or $KS(C=S)OEt$. The fluorine of **31** can also be displaced in a polar aprotic solvent with the propargylic derivative **33**, where Z is O, S or NH, in the

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presence of a base such as sodium hydride, to give **9** directly. As described for **Schemes 6** and **7** the order of synthetic operations may be changed such that the acetylenic moiety is appended after conversion of OR_{30} into the corresponding thioester, disulfide or protected thiol.

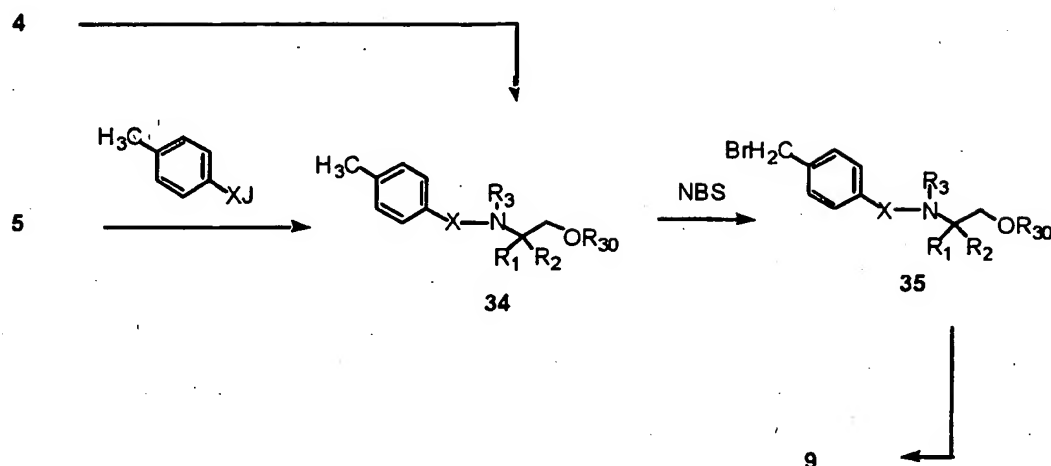
Scheme 8:



Compound **9**, wherein Z is a methylene group, is available via **34**, as shown in **Scheme 9**. Benzylic bromination of **34** with N-bromosuccinimide in a chlorinated hydrocarbon solvent provides bromide **35**. This is followed by displacement of the bromide with the appropriate propynyl cuprate to provide sulfonamide **9**.

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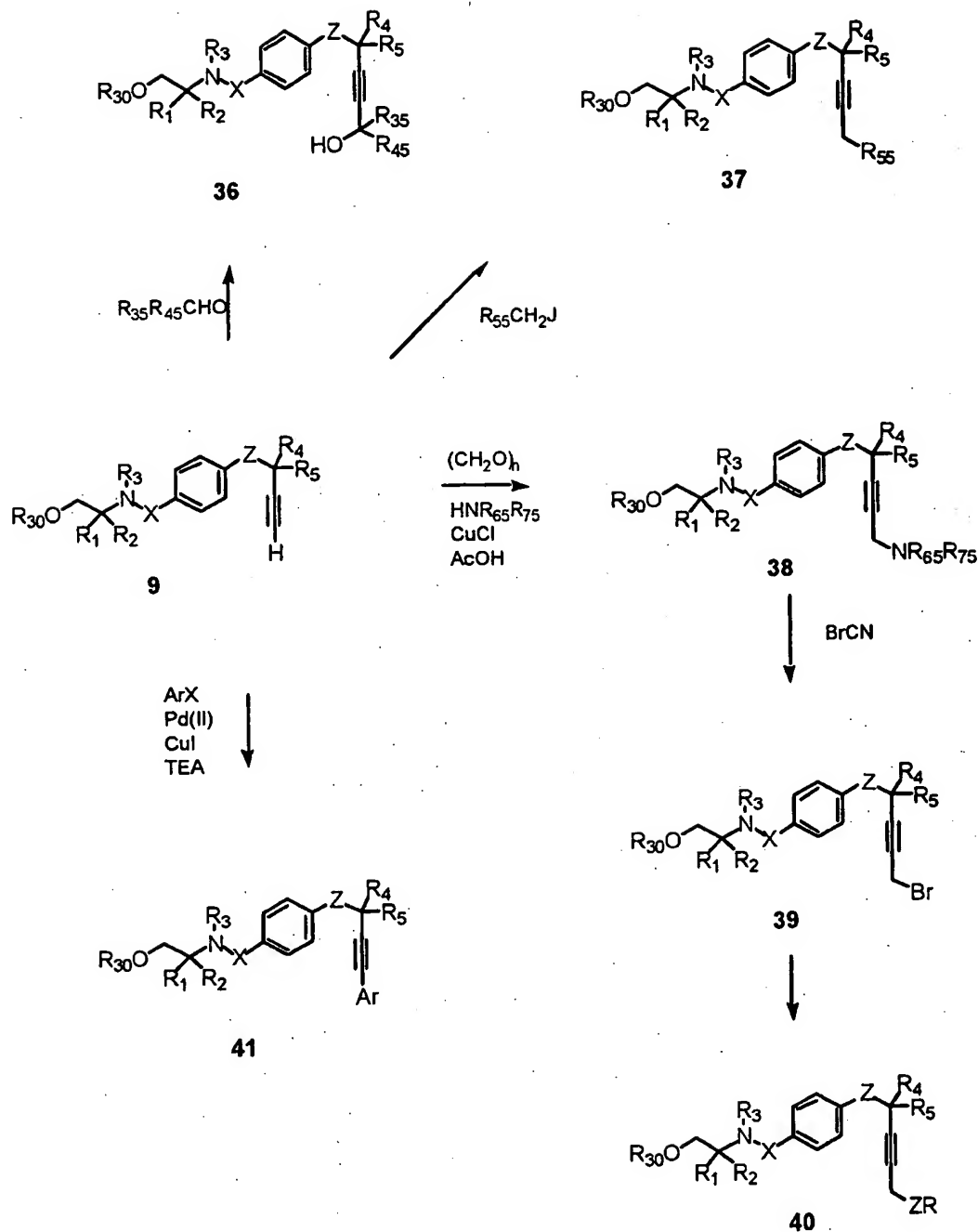
Scheme 9:



- Some of the methods available for the derivatization of compounds of structure 9 (for the case wherein R₆ is hydrogen) are shown in Scheme 10.
- 5 Metallation of the terminal acetylene 9 followed by addition of an aldehyde or alkyl halide, sulfonate or triflate provides derivatives 36 and 37. Reaction of 9 with formaldehyde and an amine provides the Mannich addition product 38. Cyanogen bromide addition to 38 gives the propargylic bromide 39 which may be displaced with a variety of nucleophiles to give, for example, ethers, thioethers and amines, 40.
 - 10 Palladium catalyzed coupling reactions of 9 provide the aryl or heteroaryl acetylenes 41. It is recognized by those skilled in the art of organic synthesis that the successful use of these methods is dependent upon the compatibility of substituents on other parts of the molecule. Protecting groups and/or changes in the order of steps described herein may be required. Examples of R₃₅, R₄₅, R₅₅, R₆₅ and R₇₅ are alkyl
 - 15 groups such as methyl.

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Scheme 10:



The following specific examples illustrate the preparation of representative compounds of this invention. The starting materials, intermediates, and reagents are either commercially available or can be readily prepared following standard literature procedures by one skilled in the art of organic synthesis.

Example 1

4-But-2-ynyloxy-benzenesulfonic acid sodium salt

To a solution of 52.35g (0.225 mol) of 4-hydroxybenzenesulfonate sodium salt in 1L of isopropanol and 225 mL of a 1.0N solution of sodium hydroxide was added 59.96g (0.45 mol) of 1-bromo-2-butyne. The resulting mixture was heated to 70° for 15h and then the isopropanol was removed by evaporation in vacuo. The resulting white precipitate was collected by filtration, washed with isopropanol and ether and dried in vacuo to give 56.0g (100%) of the butynyl ether as a white solid.

10

Example 2

4-But-2-ynyloxy-benzenesulfonyl chloride

To a 0° solution of 43.8 mL (0.087 mol) of 2M oxalyl chloride/dichloromethane solution in 29 mL of dichloromethane was dropwise added 6.77 mL (0.087 mol) of DMF followed by 7.24g (0.029 mol) of the product of Example 1. The reaction mixture was stirred for 10 minutes at 0° then let warm to room temperature and stirred for 2 days. The reaction was then poured into ice and extracted with 150 mL of hexanes. The organics were washed with water and brine, dried over Na₂SO₄, filtered and concentrated in vacuo to provide 6.23g (88%) of the sulfonyl chloride as a yellow solid; m.p. 63-65°C. EI Mass Spec: 243.9 (M⁺).

20

Example 3

But-2-ynyloxy-benzene

To a solution of 6.14g (0.023 mol) of triphenylphosphine dissolved in 100 mL of benzene and 40 mL of THF was added 1.75 mL (0.023 mol) of 2-butyne-1-ol. After five minutes 2.00 (0.023 mol) phenol, dissolved in 10 mL of THF, was added to the reaction followed by 3.69 mL (0.023 mol) of diethyl azodicarboxylate. The resulting reaction mixture was stirred for 18h at room temperature and then concentrated in vacuo. The residue was chromatographed on silica gel eluting with ethyl acetate/hexanes (1:10) to provide 2.18g (70%) of the butynyl ether as a clear liquid. EI Mass Spec: 146.0 MH⁺

30

Example 4**4-But-2-ynyloxy-benzenesulfonyl chloride**

To a solution of 0.146g (1.0 mmol) of the product of **Example 3** in 0.3 mL of dichloromethane in an acetone/ice bath under N₂ was dropwise added a solution of 0.073 mL (1.1 mmol) of chlorosulfonic acid in 0.3 mL of dichloromethane. After the addition was complete, the ice bath was removed and the reaction was stirred at room temperature for 2h. To the reaction was then dropwise added 0.113 mL (1.3 mmol) of oxalyl chloride, followed by 0.015 mL DMF. The reaction was heated to reflux for 2h and then diluted with hexane and poured into ice water. The organic layer was washed with brine, dried over sodium sulfate, and concentrated in vacuo to provide 0.130mg (53%) of the desired product as a light brown solid.

Example 5**4-But-2-ynyloxy-N-(2-hydroxy-1-methyl-ethyl)-benzenesulfonamide**

To a solution of 0.279g (3.718 mmol) of (R) -(-)-2-amino-1-propanol in 2.6 mL of THF and 0.9 mL of water was added 0.62 mL of triethylamine followed by 1.00g (4.09 mmol) of 4-but-2-ynyloxy-benzenesulfonyl chloride and the resulting mixture was stirred at room temperature for 15h. The reaction was then diluted with ethyl acetate and washed with 5% HCl solution and water, dried over MgSO₄, filtered and concentrated in vacuo. The resulting solid was washed with ether and dried in vacuo to provide 0.873g (83%) of the sulfonamide as a white solid. Electrospray Mass Spec: 283.8 (M+H)⁺

25

Example 6**4-But-2-ynyloxy-N-(2-hydroxy-1-methyl-ethyl)-N-methyl-benzenesulfonamide**

To a solution of 0.400g (1.413 mmol) of the product of **Example 5** in 3.0 mL of DMF was added 0.585g (4.240 mmol) of potassium carbonate followed by 0.132 mL (2.12 mmol) of iodomethane and the resulting mixture was stirred at room temperature for 12h. The reaction was then diluted with ether and washed with water,

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dried over MgSO_4 , filtered and concentrated in vacuo to provide 0.354g (84%) of the N-methyl sulfonamide as a white solid. Electrospray Mass Spec: 297.9 (M+H)⁺

Example 7

5 **Thioacetic acid S-{2-[(4-but-2-ynyloxy-benzenesulfonyl)-
methyl-amino]-propyl}ester**

To a 0°C solution of 0.302g (1.017 mmol) of the product of **Example 6** and 0.293g (1.118 mmol) of triphenylphosphine in 4.0 mL of THF was added 0.176 mL (1.118 mmol) of diethyl azodicarboxylate. The resulting mixture was stirred for 0.5h
10 at 0°C and then concentrated in vacuo. The residue was chromatographed on silica gel eluting with ethyl acetate/hexanes to provide 0.228g (63%) of the thioacetate as a colorless oil. Electrospray Mass Spec: 355.9 (M+H)⁺

Example 8

15 **4-But-2-ynyloxy-N-((1R)-2-mercapto-1-methyl-ethyl)-
N-methyl-benzenesulfonamide**

To a solution of 0.168g (0.473 mmol) of the product of **Example 7** in 2.1 mL of methanol was added 0.092g (1.704 mmol) of sodium methoxide. After stirring at room temperature for 2h the reaction was quenched with 5% HCl solution and
20 extracted with ether. The organics were dried over Na_2SO_4 , filtered and concentrated in vacuo. The residue was chromatographed on silica gel eluting with ethyl acetate/hexanes in a gradient from (1:10) to (1:3) to provide 0.148g (100%) of the thiol as a colorless oil. Electrospray Mass Spec: 313.9 (M+H)⁺

25

Example 9

**4-But-2-ynyloxy-N-(2-hydroxy-1-methyl-ethyl)-N-(2-morpholin-
4-yl-ethyl)-benzenesulfonamide**

According to the procedure of **Example 6**, 0.400g (1.413 mmol) of the product of **Example 5** and 0.289g (1.555 mmol) of 4-(2-chloroethyl)morpholine
30 hydrochloride provided 0.334g (60%) of the N-morpholinoethyl sulfonamide as a colorless oil. Electrospray Mass Spec: 397.0 (M+H)⁺

Example 10**S-((2R)-2-{{[4-(2-Butynyloxy)phenyl]sulfonyl}[2-(4-morpholinyl)ethyl]amino}propyl)ethanethioate**

5 To a solution of 0.416g (1.16 mmol) of the product of **Example 9** in 4 mL of THF were added sequentially 0.304g (1.16 mmol) of triphenylphosphine, 0.191g (1.16 mmol) of diethyl azodicarboxylate and 0.25 mL (3.5 mmol) of thiolacetic acid. The reaction was stirred for 45h, reduced to dryness and the resulting residue was subjected to flash chromatography eluting with ethyl acetate/ hexanes (3:1) to provide
10 0.5g (95%) of the thioacetate as a white solid. Electrospray Mass Spec: 455.3 (M+H)⁺

Example 11**4-(2-Butynyloxy)-N-[(1R)-1-methyl-2-sulfanylethyl]-N-[2-(4-morpholinyl)ethyl]benzenesulfonamide**

15 To a solution of 0.16g (0.352 mmol) of the product of **Example 10** in 2 mL of methanol in a sealable tube at -78° was added 20 mL of liquid ammonia. The tube was sealed and the reaction stirred for 12h at room temperature. After recooling to -78° the reaction tube was unsealed and the solution was carefully reduced to dryness. The residue was chromatographed on silica gel eluting with methylene chloride/methanol
20 (50:1) furnishing 121mg (84%) of the desired thiol as a white solid. Electrospray Mass Spec: 413.4 (M+H)⁺

Example 12**(2R)-2-Amino-3-(tritylsulfanyl)propanamide**

25 To 2.68g (7.37 mmol) of S-trityl-L-cysteine and 40 mL of methanol was added 7 mL (96 mmol) of thionyl chloride dropwise. After heating at reflux for 6h the solution was cooled to room temperature and then concentrated in vacuo. The resulting residue was taken up in 20 mL of methanol, treated with activated carbon, filtered and concentrated in vacuo yielding the methyl ester as an off-white foam. This
30 material was dissolved in 6 mL of methanol in a sealable tube and cooled to -78°. After 30 mL of liquid ammonia was added, the tube was sealed and the reaction was

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stirred at room temperature for 14h. After recooling to -78° the reaction tube was unsealed and the solution was carefully reduced to dryness. The residue was chromatographed on silica gel eluting with methylene chloride/methanol (10:1) furnishing 1.52g (57%) of the primary amide as a white solid. Electrospray Mass Spec:

5 363.2 (M+H)⁺

Example 13

(2R)-2-({[4-(2-Butynyloxy)phenyl]sulfonyl}amino)-3-(tritylsulfanyl)propanamide

To a solution of 1.203g (3.685 mmol) of the primary amide product from

10 **Example 12** and 1.39 mL (10 mmol) of triethylamine in 20 mL of methylene chloride was added in one portion 0.954g (3.9 mmol) of 4-but-2-ynyloxy-benzenesulfonyl chloride. After stirring for 13h, 50 mL of dichloromethane and 50 mL of water were added. The organic layer was washed with brine, dried over sodium sulfate, filtered, concentrated in vacuo and subjected to flash chromatography eluting with

15 hexanes/ethyl acetate (1:1) to furnish 1.65g (79%) of the desired sulfonamide as a white solid. Electrospray Mass Spec: 1139.6 (2M-H)⁺

Example 14

(2R)-2-({[4-(2-Butynyloxy)phenyl]sulfonyl}[2-(4-morpholinyl)ethyl]amino}-3-(tritylsulfanyl)propanamide

20

To a solution of 0.6482g (1.136 mmol) of the product from **Example 13** in 3 mL of DMF was added 0.317g (1.704 mmol) of 4-(2-chloroethyl) morpholine hydrochloride and 0.705g (5.1 mmol) of potassium carbonate. The resulting mixture was heated at 60° for 14h. After cooling to room temperature the reaction mixture was

25 diluted with ethyl acetate and washed with water. The organic layer was dried over sodium sulfate, filtered, concentrated in vacuo and subjected to flash chromatography eluting with hexanes/ethyl acetate (1:5) to furnish 0.434g (56%) of the desired compound as a white solid. Electrospray Mass Spec: 684.5 (M+H)⁺

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Example 15**(2R)-2-{{[4-(2-Butynyloxy)phenyl]sulfonyl}[2-(4-morpholinyl)ethyl]amino}-3-sulfanylpropanamide**

To a solution of 0.116g (0.170 mmol) of the product from Example 14 in 1.5 mL of methylene chloride was added triisopropylsilane, followed by trifluoroacetic acid. Upon consumption of starting material the solution was concentrated in vacuo and washed four times with 2mL of ether. The residue was partitioned between ethyl acetate and saturated aqueous sodium bicarbonate. The organic layer was dried over sodium sulfate, filtered and concentrated in vacuo furnishing 66 mg (88%) of the thiol as a white solid. Electrospray Mass Spec: 442.4 (M+H)⁺

Pharmacology

The ability of the compounds of the invention, or their pharmaceutically acceptable salts, to inhibit matrix metalloproteinases or TACE and, consequently, demonstrate their effectiveness for treating diseases modulated by matrix metalloproteinases or TACE is shown by the following in vitro assays.

Test Procedures for Measuring MMP-1, MMP-9, and MMP-13 Inhibition

These standard pharmacological test procedures are based on the cleavage of a thiopeptide substrates such as Ac-Pro-Leu-Gly(2-mercapto-4-methyl-pentanoyl)-Leu-Gly-OEt by the matrix metalloproteinases MMP-1, MMP-13 (collagenases) or MMP-9 (gelatinase), which results in the release of a substrate product that reacts colorimetrically with DTNB (5,5'-dithiobis(2-nitro-benzoic acid)). The enzyme activity is measured by the rate of the color increase. The thiopeptide substrate is made up fresh as a 20 mM stock in 100% DMSO and the DTNB is dissolved in 100% DMSO as a 100 mM stock and stored in the dark at room temperature. Both the substrate and DTNB are diluted together to 1 mM with substrate buffer (50 mM HEPES pH 7.5, 5 mM CaCl₂) before use. The stock of enzyme is diluted with buffer (50 mM HEPES, pH 7.5, 5 mM CaCl₂, 0.02% Brij) to the desired final concentration. The buffer, enzyme, vehicle or inhibitor, and DTNB/substrate are added in this order to a 96 well plate (total reaction volume of 200 µl) and the

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increase in color is monitored spectrophotometrically for 5 minutes at 405 nm on a plate reader and the increase in color over time is plotted as a linear line.

Alternatively, a fluorescent peptide substrate is used. In this test procedure, the peptide substrate contains a fluorescent group and a quenching group. Upon
5 cleavage of the substrate by an MMP, the fluorescence that is generated is quantitated on the fluorescence plate reader. The assay is run in HCBC assay buffer (50mM HEPES, pH 7.0, 5 mM Ca^{+2} , 0.02% Brij, 0.5% Cysteine), with human recombinant MMP-1, MMP-9, or MMP-13. The substrate is dissolved in methanol and stored
10 frozen in 1 mM aliquots. For the assay, substrate and enzymes are diluted in HCBC buffer to the desired concentrations. Compounds are added to the 96 well plate containing enzyme and the reaction is started by the addition of substrate. The reaction is read (excitation 340 nm, emission 444 nm) for 10 min. and the increase in fluorescence over time is plotted as a linear line.

For either the thiopeptide or fluorescent peptide test procedures, the slope of
15 the line is calculated and represents the reaction rate. The linearity of the reaction rate is confirmed ($r^2 > 0.85$). The mean ($x \pm \text{sem}$) of the control rate is calculated and compared for statistical significance ($p < 0.05$) with drug-treated rates using Dunnett's multiple comparison test. Dose-response relationships can be generated using multiple doses of drug and IC_{50} values with 95% CI are estimated using linear
20 regression.

Test Procedure for Measuring TACE Inhibition

Using 96-well black microtiter plates, each well receives a solution composed of 10 μL TACE (final concentration $1\mu\text{g/mL}$), 70 μL Tris buffer, pH 7.4 containing 10% glycerol (final concentration 10 mM), and 10 μL of test compound solution in
25 DMSO (final concentration $1\mu\text{M}$, DMSO concentration $<1\%$) and incubated for 10 minutes at room temperature. The reaction is initiated by addition of a fluorescent peptidyl substrate (final concentration $100\mu\text{M}$) to each well and then shaking on a shaker for 5 sec.

The reaction is read (excitation 340 nm, emission 420 nm) for 10 min. and the
30 increase in fluorescence over time is plotted as a linear line. The slope of the line is calculated and represents the reaction rate.

The linearity of the reaction rate is confirmed ($r^2 > 0.85$). The mean ($x \pm \text{sem}$) of the control rate is calculated and compared for statistical significance ($p < 0.05$)

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with drug-treated rates using Dunnett's multiple comparison test. Dose-response relationships can be generated using multiple doses of drug and IC₅₀ values with 95% CI are estimated using linear regression.

5 Human Monocytic THP-1 Cell Differentiation Assay For Soluble Proteins (THP-1 Soluble Protein Assay)

Mitogenic stimulation of THP-1 cells cause differentiation into macrophage like cells with concomitant secretion of tumor necrosis factor (TNF- α) and TNF receptor (TNF-R p75/80 and TNF-R p55/60) and Interleukin-8 (IL-8), among other
10 proteins. In addition, non-stimulated THP-1 cells shed both the p75/80 and the p55/60 receptors over time. The release of membrane bound TNF- α and possibly TNF-R p75/80 and TNF-R p55/60, but not IL-8, is mediated by an enzyme called TNF- α converting enzyme or TACE. This assay can be used to demonstrate either an
15 inhibitory or a stimulatory compound effect on this TACE enzyme and any cytotoxic consequence of such a compound.

THP-1 cells (from ATCC) are a human monocytic cell line which were obtained from the peripheral blood of a one year old male with acute monocytic leukemia. They can be grown in culture and differentiated into macrophage like cells by stimulation with mitogens.

20 For the assay, THP-1 cells are seeded from an ATCC stock which was previously grown and frozen back at 5×10^6 /ml/vial. One vial is seeded into a T25-flask with 16 mls of RPMI-1640 with glutamax (Gibco) media containing 10 % fetal bovine serum, 100 units/ml penicillin, 100 μ g/ml streptomycin, and 5×10^{-5} M 2-mercapto-ethanol (THP-1 media). Each vial of cells are cultured for about two weeks
25 prior to being used for an assay and then are used for only 4 to 6 weeks to screen compounds. Cells are subcultured on Mondays and Thursdays to a concentration of 1×10^5 /ml.

To perform an assay, the THP-1 cells are co-incubated in a 24 well plate with 50 μ l/well of a 24 mg/ml stock of Lipopolysaccharide (LPS) (Calbiochem Lot#
30 B13189) at 37°C in 5% CO₂ at a concentration of 1.091×10^6 cells/ml (1.1 ml/well) for a total of 24 hours. At the same time, 50 μ l/well of drug, vehicle or THP-1 media is plated in appropriate wells to give a final volume of 1.2 ml/well. Standard and test compounds are dissolved in DMSO at a concentration of 36 mM and diluted from here to the appropriate concentrations in THP-1 media and added to the wells at
35 the beginning of the incubation period to give final concentrations of 100 mM, 30 mM, 10 mM, 3 mM, 1 mM, 300 nM, and 100 nM. Cell exposure to DMSO was

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limited to 0.1 % final concentration. Positive control wells were included in the experiment which had mitogen added but no drug. Vehicle control wells were included as well, which were identical to the positive control wells, except that DMSO was added to give a final concentration of 0.083%. Negative control wells
5 were included in the experiment which had vehicle but no mitogen or drug added to the cells. Compounds can be evaluated for their effect on basal (non-stimulated) shedding of the receptors by replacing the LPS with 50 ml/well of THP-1 media. Plates are placed into an incubator set at 5% CO₂ and at 37°C. After 4 hours of incubation, 300 ml/well of tissue culture supernatant (TCS) is removed for use in an
10 TNF- α ELISA. Following 24 hours of incubation, 700 ml/well of TCS is removed and used for analysis in TNF-R p75/80, TNF-R p55/60 and IL-8 ELISAs.

In addition, at the 24 hours timepoint, and the cells for each treatment group are collected, by resuspension in 500 μ l/well of THP-1 media and transferred into a FACS tube. Two ml/tube of a 0.5 mg/ml stock of propidium iodide (PI) (Boehringer
15 Mannheim cat. # 1348639) is added. The samples are run on a Becton Dickinson FaxCaliber FLOW cytometry machine and the amount of dye taken up by each cell is measured in the high red wavelength (FL3). Only cells with compromised membranes (dead or dying) can take up PI. The percent of live cells is calculated by the number of cells not stained with PI, divided by the total number of cells in the
20 sample. The viability values calculated for the drug treated groups were compared to the viability value calculated for the vehicle treated mitogen stimulated group ("vehicle positive control") to determine the "percent change from control". This "percent change from control" value is an indicator of drug toxicity.

The quantity of soluble TNF- α , TNF-R p75/80 and TNF-R p55/60 and IL-8
25 in the TCS of the THP-1 cell cultures are obtained with commercially available ELISAs from R&D Systems, by extrapolation from a standard curve generated with kit standards. The number of cells that either take up or exclude PI are measured by the FLOW cytometry machine and visualized by histograms using commercially available Cytologic software for each treatment group including all controls.

30 Biological variability in the magnitude of the response of THP-1 cell cultures requires that experiments be compared on the basis of percent change from "vehicle positive control" for each drug concentration. Percent change in each soluble protein evaluated from the "vehicle positive control" was calculated for each compound concentration with the following formula:

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$$\% \text{ Change} = \frac{\text{pg/ml (compound)} - \text{pg/ml (veh pos control)}}{\text{pg/ml (veh pos control)} - \text{pg/ml (veh neg control)}} \times 100$$

For the soluble protein (TNF- α , p75/80, p55/60, IL-8) studies under stimulated conditions, the mean pg/ml of duplicate wells were determined and the results expressed as percent change from "vehicle positive control". For the soluble protein (p75/80 and p55/60 receptors) studies under non-stimulated conditions, the mean pg/ml of duplicate wells were determined and the results expressed as percent change from "vehicle positive control" utilizing the following formula:

$$\% \text{ Change} = \frac{\text{pg/ml (compound neg control)} - \text{pg/ml (veh neg control)}}{\text{pg/ml (veh neg control)}} \times 100$$

IC₅₀ values for each compound are calculated by non-linear regression analysis using customized software utilizing the JUMP statistical package.

For the cell viability studies, the viabilities (PI exclusion) of pooled duplicate wells were determined and the results expressed as % change from "vehicle positive control". The viability values calculated for the compound treated groups were compared to the viability value calculated for the "vehicle positive control" to determine "percent change from control" as below. This value "percent change from control" is an indicator of drug toxicity.

$$\% \text{ Change} = \frac{\% \text{ live cells (compound)}}{\% \text{ live cells (veh pos control)}} - 1 \times 100$$

References:

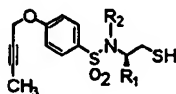
Bjornberg, F., Lantz, M., Olsson, I., and Gullberg, U. Mechanisms involved in the processing of the p55 and the p75 tumor necrosis factor (TNF) receptors to soluble receptor forms. *Lymphokine Cytokine Res.* 13:203-211, 1994.

Gatanaga, T., Hwang, C., Gatanaga, M., Cappuccini, F., Yamamoto, R., and Granger, G. The regulation of TNF mRNA synthesis, membrane expression, and release by PMA- and LPS-stimulated human monocytic THP-1 cells in vitro. *Cellular Immun.* 138:1-10, 1991.

Tsuchiya, S., Yamabe, M., Yamaguchi, Y., Kobayashi, Y., Konno, T., and Tada, K. Establishment and characterization of a human acute monocytic leukemia cell line (THP-1). *Int. J. Cancer.* 26:1711-176, 1980.

Results of the above in vitro matrix metalloproteinase inhibition, TACE inhibition and THP standard pharmacological test procedures are given in Table 1 below.

Table 1.



Example #	R ₁	R ₂	MMP-1 ^a	MMP-9 ^a	MMP-13 ^a	TACE ^a	THP
8	CH ₃	CH ₃	6,300	2,700	679	273	3
11	CH ₃	(CH ₂) ₂ Morph	-	-	-	362	11
15	CONH ₂	(CH ₂) ₂ Morph	-	-	-	263	19

a) IC₅₀ (nM)

Based on the standard pharmacological test procedures described above, the compounds of this invention are useful in the treatment of disorders such as arthritis, tumor metastasis, tissue ulceration, abnormal wound healing, periodontal disease, graft rejection, insulin resistance, bone disease and HIV infection.

The compounds of this invention are also useful in treating or inhibiting pathological changes mediated by matrix metalloproteinases such as atherosclerosis, atherosclerotic plaque formation, reduction of coronary thrombosis from atherosclerotic plaque rupture, restenosis, MMP-mediated osteopenias, inflammatory diseases of the central nervous system, skin aging, angiogenesis, tumor metastasis, tumor growth; osteoarthritis, rheumatoid arthritis, septic arthritis, corneal ulceration, proteinuria, aneurysmal aortic disease, degenerative cartilage loss following traumatic joint injury, demyelinating diseases of the nervous system, cirrhosis of the liver, glomerular disease of the kidney, premature rupture of fetal membranes, inflammatory bowel disease, age related macular degeneration, diabetic retinopathy, proliferative vitreoretinopathy, retinopathy of prematurity, ocular inflammation, keratoconus, Sjogren's syndrome, myopia, ocular tumors, ocular angiogenesis/neovascularization and corneal graft rejection.

Compounds of this invention may be administered neat or with a pharmaceutical carrier to a patient in need thereof. The pharmaceutical carrier may be solid or liquid.

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Applicable solid carriers can include one or more substances which may also act as flavoring agents, lubricants, solubilizers, suspending agents, fillers, glidants, compression aids, binders or tablet-disintegrating agents or an encapsulating material. In powders, the carrier is a finely divided solid which is in admixture with the finely divided active ingredient. In tablets, the active ingredient is mixed with a carrier having the necessary compression properties in suitable proportions and compacted in the shape and size desired. The powders and tablets preferably contain up to 99% of the active ingredient. Suitable solid carriers include, for example, calcium phosphate, magnesium stearate, talc, sugars, lactose, dextrin, starch, gelatin, cellulose, methyl cellulose, sodium carboxymethyl cellulose, polyvinylpyrrolidone, low melting waxes and ion exchange resins.

Liquid carriers may be used in preparing solutions, suspensions, emulsions, syrups and elixirs. The active ingredient of this invention can be dissolved or suspended in a pharmaceutically acceptable liquid carrier such as water, an organic solvent, a mixture of both or pharmaceutically acceptable oils or fat. The liquid carrier can contain other suitable pharmaceutical additives such as solubilizers, emulsifiers, buffers, preservatives, sweeteners, flavoring agents, suspending agents, thickening agents, colors, viscosity regulators, stabilizers or osmo-regulators. Suitable examples of liquid carriers for oral and parenteral administration include water (particularly containing additives as above, e.g., cellulose derivatives, preferable sodium carboxymethyl cellulose solution), alcohols (including monohydric alcohols and polyhydric alcohols, e.g., glycols) and their derivatives, and oils (e.g., fractionated coconut oil and arachis oil). For parenteral administration the carrier can also be an oily ester such as ethyl oleate and isopropyl myristate. Sterile liquid carriers are used in sterile liquid form compositions for parenteral administration.

Liquid pharmaceutical compositions which are sterile solutions or suspensions can be utilized by, for example, intramuscular, intraperitoneal or subcutaneous injection. Sterile solutions can also be administered intravenously. Oral administration may be either liquid or solid composition form.

The compounds of this invention may be administered rectally in the form of a conventional suppository. For administration by intranasal or intrabronchial

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inhalation or insufflation, the compounds of this invention may be formulated into an aqueous or partially aqueous solution, which can then be utilized in the form of an aerosol. The compounds of this invention may also be administered transdermally through the use of a transdermal patch containing the active compound and a carrier that is inert to the active compound, is non-toxic to the skin, and allows delivery of the agent for systemic absorption into the blood stream via the skin. The carrier may take any number of forms such as creams and ointments, pastes, gels, and occlusive devices. The creams and ointments may be viscous liquid or semi-solid emulsions of either the oil in water or water in oil type. Pastes comprised of absorptive powders dispersed in petroleum or hydrophilic petroleum containing the active ingredient may also be suitable. A variety of occlusive devices may be used to release the active ingredient into the blood stream such as a semipermeable membrane covering a reservoir containing the active ingredient with or without a carrier, or a matrix containing the active ingredient. Other occlusive devices are known in the literature.

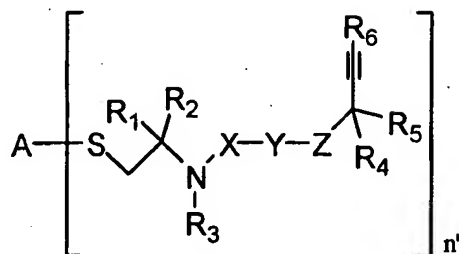
The dosage to be used in the treatment of a specific patient suffering a MMP or TACE dependent condition must be subjectively determined by the attending physician. The variables involved include the severity of the dysfunction, and the size, age, and response pattern of the patient. Treatment will generally be initiated with small dosages less than the optimum dose of the compound. Thereafter the dosage is increased until the optimum effect under the circumstances is reached. Precise dosages for oral, parenteral, nasal, or intrabronchial administration will be determined by the administering physician based on experience with the individual subject treated and standard medical principles.

Preferably the pharmaceutical composition is in unit dosage form, e.g., as tablets or capsules. In such form, the composition is sub-divided in unit dose containing appropriate quantities of the active ingredient; the unit dosage form can be packaged compositions, for example packed powders, vials, ampoules, prefilled syringes or sachets containing liquids. The unit dosage form can be, for example, a capsule or tablet itself, or it can be the appropriate number of any such compositions in package form.

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CLAIMS

1. A compound having the formula **B**:



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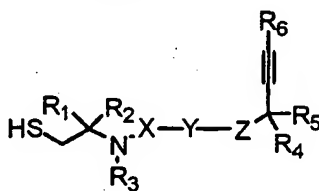
B

wherein $n' = 1$ or 2 ;

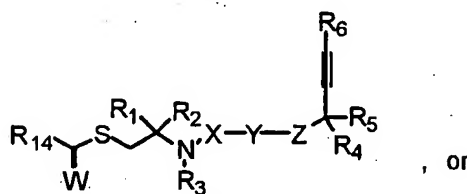
and when $n' = 2$, then A is absent (ie. a disulfide);

and when $n' = 1$, then A is H or $\text{R}_{14}\text{C}(=\text{W})-$;

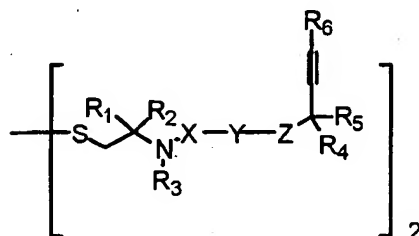
(ie wherein **B** is one of the following:



1a



1b



1c

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in which formulae:

W is oxygen or sulfur;

X is SO_2 or $-\text{P}(\text{O})-\text{R}_{10}$;

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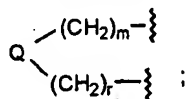
Y is aryl or heteroaryl as defined below, with the proviso that X and Z may not be bonded to adjacent atoms of Y;

Z is O, NH, CH₂ or S;

R₁ is hydrogen, aryl, alkyl of 1-6 carbon atoms, alkenyl of 2-6 carbon atoms, alkynyl of 2-6 carbon atoms;

R₂ is hydrogen, aryl or heteroaryl as defined below, cycloalkyl of 3-6 carbon atoms, -C₅-C₈-cycloheteroalkyl, alkyl of 1-6 carbon atoms, alkenyl of 2-6 carbon atoms, alkynyl of 2-6 carbon atoms, or CONR₃R₄;

or R₁ and R₂, together with the atom to which they are attached, may form a ring wherein R₁ and R₂ represent a divalent moiety of the formula:



wherein

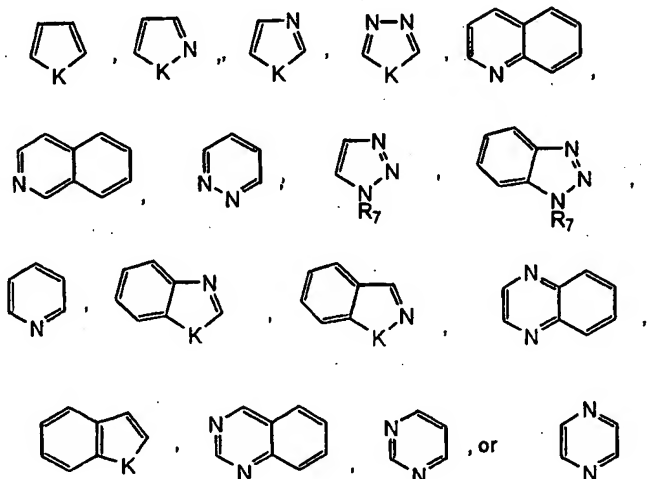
Q = a carbon-carbon single or double bond, O, S, SO, -N-R₁₁, or -CONR₁₅;

m = 1-3;

r = 1 or 2, with the proviso that when Q is a bond, r is equal to 2;

Aryl is phenyl or naphthyl optionally substituted by one to two substituents selected from R₇, where R₇ is as defined below;

Heteroaryl is defined as

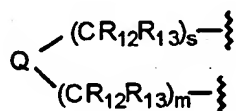


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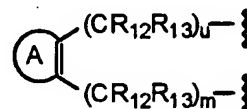
optionally mono- or di- substituted by R_7 , wherein K is defined as O, S or $-NR_{15}$;

R_3 is hydrogen or alkyl of 1-6 carbon atoms;

or R_1 and R_3 , together with the atoms to which they are attached, may form a 5 to 8 membered ring wherein R_1 and R_3 represent divalent moieties of the formulae:



and



wherein Q and m are as defined above;

A is aryl or heteroaryl;

s is 0-3;

u is 1-4;

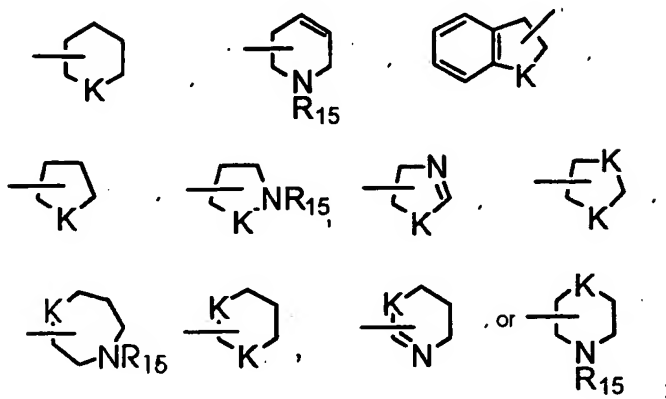
R_4 and R_5 are each, independently, hydrogen, alkyl of 1-6 carbon atoms, $-CN$, $-CCH$;

R_6 is hydrogen, aryl, heteroaryl, alkyl of 1-6 carbon atoms, alkenyl of 2-6 carbon atoms, alkynyl of 2-6 carbon atoms, cycloalkyl of 3-6 carbon atoms or C_5 - C_8 -cycloheteroalkyl as defined below;

R_7 is hydrogen, halogen, alkyl of 1-6 carbon atoms; alkenyl of 2-6 carbon atoms; alkynyl of 2-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, $-OR_8$, $-CN$, $-COR_8$, perfluoroalkyl of 1-4 carbon atoms, $-O$ -perfluoroalkyl of 1-4 carbon atoms, $-CONR_8R_9$, $-S(O)_nR_8$, $-OPO(OR_8)OR_9$, $-PO(OR_8)R_9$, $-OC(O)NR_8R_9$, $-C(O)NR_8OR_9$, $-COOR_8$, $-SO_3H$, $-NR_8R_9$, $-N[(CH_2)_2]_2NR_8$, $-NR_8COR_9$, $-NR_8COOR_9$, $-SO_2NR_8R_9$, $-NO_2$, $-N(R_8)SO_2R_9$, $-NR_8CONR_8R_9$, $-NR_8C(=NR_9)NR_8R_9$, tetrazol-5-yl, $-SO_2NHCN$, $-SO_2NHCONR_8R_9$, phenyl, heteroaryl as defined above, or C_5 - C_8 -cycloheteroalkyl as defined below;

wherein $-NR_8R_9$ may form a pyrrolidine, piperidine, morpholine, thiomorpholine, oxazolidine, thiazolidine, pyrazolidine, piperazine, or azetidine ring;

wherein -C₅-C₈-cycloheteroalkyl is defined as



5 wherein K is defined as above;

R_8 and R_9 are each, independently, hydrogen, alkyl of 1-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, aryl, heteroaryl or -C₅-C₈-cycloheteroalkyl;

R_{10} is alkyl of 1-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, aryl or heteroaryl as defined above;

R_{11} is hydrogen, alkyl of 1-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, aryl, heteroaryl, -S(O)₂R₈, -COOR₈, -CONR₈R₉, -SO₂NR₈R₉ or -COR₈;

R_{12} and R_{13} are independently selected from H, -OR₈, -NR₈R₉, alkyl of 1-6 carbon atoms, alkenyl of 2-6 carbon atoms, alkynyl of 2-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, aryl, heteroaryl, -COOR₈, -CONR₈R₉; or R_{12} and R_{13} together form a -C₃-C₆-cycloalkyl of 3-6 carbon atoms or a -C₅-C₈-cycloheteroalkyl ring; or R_{12} and R_{13} together with the carbon to which they are attached, form a carbonyl group;

20 with the proviso that R_{10} and R_{12} or R_{11} and R_{12} may form a cycloheteroalkyl ring, wherein cycloheteroalkyl is as defined above, when they are attached to adjacent atoms;

25 R_{14} is -OR₈, -NR₈R₉, alkyl of 1-6 carbon atoms, cycloalkyl of 3-6 carbon atoms, aryl or heteroaryl;

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R_{13} is hydrogen, aryl, heteroaryl, alkyl of 1-6 carbon atoms or cycloalkyl of 3-6 carbon atoms;

and n is 0-2;

or a pharmaceutically acceptable salt thereof.

5

2. A compound according to Claim 1 of formula **1a** wherein Y is phenyl or a pharmaceutically acceptable salt thereof.

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3. A compound according to Claim 1 or Claim 2 wherein X is SO_2 ; or a pharmaceutically acceptable salt thereof.

4. A compound according to any one of Claims 1 to 3 wherein Z is oxygen; or a pharmaceutically acceptable salt thereof.

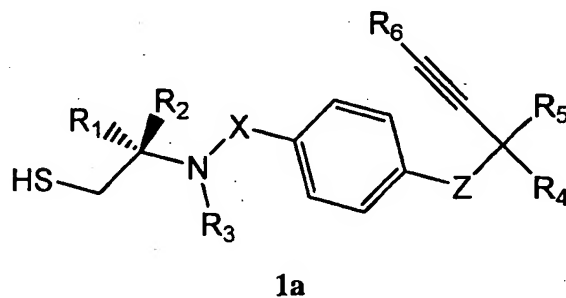
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5. A compound according to any one of Claims 1 to 4 wherein R_4 and R_5 are hydrogen; or a pharmaceutically acceptable salt thereof.

6. A compound according to any one of Claims 1 to 5 wherein R_6 is $-CH_2OH$ or methyl; or a pharmaceutically acceptable salt thereof.

20

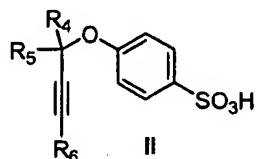
7. A compound according to Claim 1 wherein R_1 is hydrogen, such that this compound has the absolute stereochemistry as shown in structure **1a** below.



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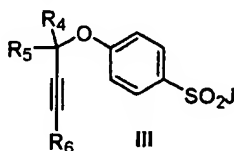
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8. A compound of formula II, with the proviso that R_6 is not hydrogen and R_4 , R_5 and R_6 are as defined in Claim 1.



5

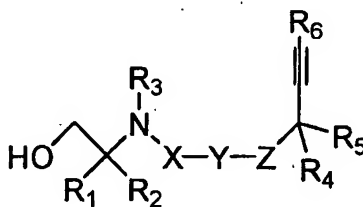
9. A compound of formula III, with the proviso that R_6 is not hydrogen wherein J is fluorine, bromine, chlorine, 1,2,4-triazolyl, benzotriazolyl or imidazolyl, and R_4 , R_5 and R_6 are as defined in Claim 1.



10

10. A process for preparing compounds of formula B as defined in Claim 1 which comprises one of the following:

a) reacting a compound of formula V:



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(V)

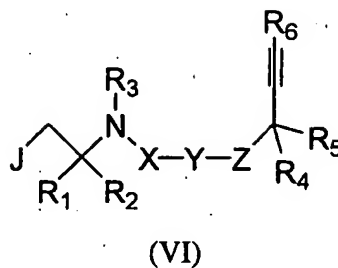
wherein R_1 - R_6 , X, Y and Z are defined in claim 1, with a compound of formula $R_{14}C(W)SH$ under conditions suitable for the Mitsunobu reaction to give a corresponding compound of formula 1b (i.e. formula B wherein $n'=1$ and A is

20 $R_{14}C(=W)-$;

or

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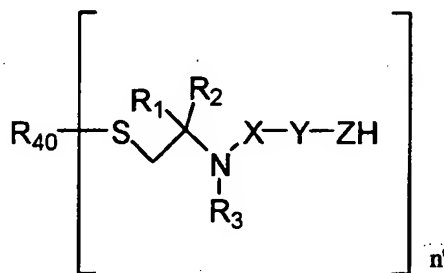
b) reacting a compound of formula VI:



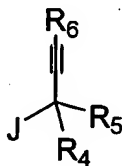
wherein R_1 - R_6 , X, Y and Z are defined in claim 1, and J is a leaving group, with a compound of formula $A'SH$ where A' is an alkali metal or a $R_{14}C(W)-$ group or a salt thereof to give a corresponding compound of formula 1a or 1b, (i.e. formula B wherein $n'=1$ and A is H or $R_{14}C(=W)-$);

or

c) reacting a compound of formula VII:



wherein R_1 , R_2 , R_3 , X, Y, Z and n' is as defined in claim 1, and when $n'=1$ R_{40} is H or $R_{14}C(=W)-$, and when $n'=2$, R_{40} is absent (i.e. a disulfide), with a compound of formula VIII:



wherein R_4 , R_5 , and R_6 are as defined above and J is a leaving group such as described above, to give a corresponding compound of formula B;

or

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- d) hydrolysing a compound of formula **B** wherein R_1 - R_6 , X, Y and Z are defined in claim 1, $n'=1$ and A is $R_{14}C(=W)-$ (i.e. formula **1b**), to give a corresponding compound of formula **1a** (i.e. formula **B** wherein A is H);
or
- 5 e) reducing a compound of formula **B** wherein R_1 - R_6 , X, Y and Z are defined in claim 1, $n'=1$ and A is $R_{14}C(=W)-$ (i.e. formula **1b**) or n' is 2 (i.e. formula **1c**), to give a corresponding compound of formula **1a** (i.e. formula **B** wherein A is H);
or
- 10 f) oxidising a compound of formula **B** wherein R_1 - R_6 , X, Y and Z are defined in claim 1, $n'=1$ and A is H (i.e. formula **1a**), to give a corresponding compound of formula **1c** (i.e. formula **B** wherein $n'=2$);
or
- 15 g) resolving a mixture (e.g racemate) of optically active isomers of a compound of formula **B** to isolate one enantiomer or diastereomer substantially free of the other enantiomer or diastereomers;
or
- h) acidifying a basic compound of formula **B** with a pharmaceutically acceptable acid to give a pharmaceutically acceptable salt.
- 20 11. A method of inhibiting pathological changes mediated by $TNF-\alpha$ converting enzyme (TACE) in a mammal in need thereof which comprises administering to said mammal a therapeutically effective amount of a compound according to Claim 1.
- 25 12. The method according to Claim 11 wherein the condition treated is rheumatoid arthritis, graft rejection, cachexia, inflammation, fever, insulin resistance, septic shock, congestive heart failure, inflammatory disease of the central nervous system, inflammatory bowel disease or HIV infection.
- 30 13. A pharmaceutical composition comprising a compound as claimed in claim 1 or a salt thereof and a pharmaceutically acceptable carrier.

14. A compound according to Claim 1 which is 4-But-2-ynyloxy-N-((1R)-2-mercapto-1-methyl-ethyl)-N-methylbenzene-sulfonamide.

5 15. A compound of Claim 1 which is (2R)-2-{{[4-(2-Butynyloxy)phenyl]-sulfonyl}[2-(4-morpholinyl)ethyl]amino}-3-sulfanylpropanamide.

16. A compound of Claim 1 which is 4-(2-Butynyloxy)-N-[(1R)-1-methyl-2-sulfanylethyl]-N-[2-(4-morpholinyl)ethyl]benzenesulfonamide.

INTERNATIONAL SEARCH REPORT

Inte .onal Application No
PCT/US 00/02143

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C07C323/49 C07C327/06 C07D295/12 C07F9/53 A61K31/18
A61P19/02 A61P37/00 C07C309/42 C07C309/87

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07C C07D C07F A61K A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 98 03166 A (MONSANTO) 29 January 1998 (1998-01-29) cited in the application page 5 -page 10	1,11
A	WO 98 03164 A (MONSANTO) 29 January 1998 (1998-01-29) page 5 -page 10	1,11

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

29 May 2000

Date of mailing of the international search report

08/06/2000

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Authorized officer

English, R

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 00/02143

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this International application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

information on patent family members

International Application No

PCT/US 00/02143

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9803166 A	29-01-1998	AU 3890397 A	10-02-1998
		CN 1238688 A	15-12-1999
		CZ 9900168 A	11-08-1999
		EP 0939629 A	08-09-1999
		NO 990247 A	19-03-1999
		PL 331338 A	05-07-1999
WO 9803164 A	29-01-1998	AU 714687 B	06-01-2000
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		NO 990262 A	17-03-1999
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